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AGRICULTURE

THE JOURNAL OF THE MINISTRY OF AGRICULTURE

VOL. LVI No. 9 DECEMBER 1949

THE PLANNING OF LAND USE

This year's Presidential address to the Geography Section of the British Association for the Advancement of Science

PROFESSOR L. DUDLEY STAMP, C.B.E., D.Sc., B.A.

IT has been said that any country has but two ultimate assets—its land and its people. The use made of the former depends upon the intelligence, the skill and the objectives of the latter. Obviously "land" in this sense includes the resources which lie below the surface as well as those of the surface and of the associated bodies of water. The planning of land use is thus, in fact, planning for the full development and use of natural resources. Only slowly are we coming to the realization that the resources of the world are finite and that the continuance of the human race in the long run must depend upon the intelligent planned use of those resources—especially of food-producing land. This is essentially a long-term view and it is not surprising to find frequently a sharp conflict with a short-term economic viewpoint. There is also a conflict at times with the professional planner, especially the urban town planner, whose basic training is as an architect or surveyor, and who through failure to appreciate such natural factors as the disposition of minerals, or the qualities of soil and land, may achieve a particular aim in planning only at the expense of sterilizing resources in the long run vital to the human race.

The planning of land use in any country must be viewed against a world background—a world population of 2,200 millions, increasing at a rate of 20 millions a year; more rapidly than the application of science to production can augment food supply and at a time when there are no more virgin lands available for easy conquest, only tropical lands where reclamation must inevitably be slow and costly even if eventually successful. The word planning has to some extent incurred popular disfavour. Its association with the advocacy of some particular recipe for erasing ills, its supposed dependence on theory and divorce from reality, still more the concept of a plan as a straight-jacket regulating our present and our future, have all contributed to this unfortunate position. In reality the world as a whole (and each country individually) is faced with the urgent need of developing and using its natural resources more scientifically and more intelligently than in the past. This is planning: the long-term plan is simply the formulation of certain principles, and the short-term plan a specific development within the general.

Land use planning is not an end in itself; its purpose is to secure what is loosely called an improved standard of living for mankind. I have discussed on more than one previous occasion what are the basic needs of man which must be satisfied by a proper use of land and have suggested that there are at least six. One is work, which brings to the forefront the

location of industry and the fact that the majority of industries are tied by natural factors such as the occurrence of coal, or other minerals, the need for a waterside location, and so on. A second is a home and hence the whole need of land for housing and town planning in the restricted sense. A third is food—even more basic for human survival, though apt to be forgotten by a nation which thinks only of food coming out of shops—and with food raw materials of animal and vegetable origin. With man's need of food we naturally link need of water. A fourth need of man is recreation for mind and body, which again has its land use aspects. A fifth need is mobility—means of communication—and so land for railways, roads and airfields. A sixth need is security and brings into the picture the requirements of the fighting services for training grounds.

Modern land planning involves the balancing of each of these claims on its quota of a strictly limited area of land. We may urge that for any given tract of land there is an optimum use in the national interest, though use at any given time is not necessarily permanent and many types of land can serve more than one use at the same time (multiple use of hill grazing for sheep, water supply and recreation is an example).

The problem is obviously acute in such a country as Britain but none the less real all over the world. Conservation of natural resources by individual countries cannot in the long run be inconsistent with world progress.

Although these principles sound extremely simple and obvious, the problem of their application is, in fact, very difficult. Determination of optimum use involves the weighing up of many, often conflicting, claims and there is very real danger that the conscious planning of land use, to which we are definitely committed in this country, may completely fail in its objective of improving our standard of living. Despite the existence of a Ministry of Town and Country Planning charged with the task of co-ordinating competing demands of land, our planners tend each to urge his own particular aim. Housing schemes conflict with food production; security needs conflict with amenity interests, and much that we are doing may well have to be undone if chaos is not to result.

Rural Population Densities and Rural Planning

In a country such as Britain we stand in the supremely dangerous position that long-range plans may be formulated and our destiny marked out for many years to come without an adequate foundation of factual knowledge and scientific interpretation. This is well illustrated by the present chaotic state of "rural planning".

It would seem obvious that, if every acre of good agricultural land is important in food production, new building in the countryside—in villages and the open country—should be restricted to building for agricultural purposes, including, of course, homes for agricultural workers. To avoid "pepperpot" and "ribbon" development, and at the same time to facilitate provision of essential services, such as electricity, piped water and main drainage, new building should obviously be in existing villages. Let us see where these two, apparently obvious, principles may lead us.

The population of rural areas falls into three main groups:

1. *The Primary Rural Population* of farmers, farm workers and their families with, in appropriate areas, forest workers—the people who depend primarily and directly on the land for a livelihood.
2. *The Secondary Rural Population*, which exists to serve the primary population and so to complete the essential make-up of the rural community. To be included are resident landlords, village shopkeepers, smiths, wheelwrights, workers in garages and servicing stations, certain of the middlemen serving rural needs, contractors for agricultual operations, together with the parson, publican, doctor, vet, school-teachers and postmen essential to village life.

3. *The Adventitious Population*, people who live in the country by choice. Included are many who have retired from active life from the country itself (retired farmers), from the towns or from abroad, but also many who, whilst working in nearby towns, prefer to live, and especially for their families to live, in rural surroundings.

Since the Primary and Secondary Rural Populations depend essentially on the capacity of the land to support them, the first question to be answered is how many farmers can the land support? Figures for farmers in Census and Agricultural Returns must be used with caution because of the inclusion, especially in the latter, of many smallholdings worked as a hobby, or part-time occupation, or to supplement a pension, by those who are not primarily farmers. For the first time, the 1941 Farm Survey gave basic data for England and Wales on *full-time farmers*. They numbered 215,900, and they were cultivating 21,296,000 acres of crops and grass or 88 per cent of the total cultivated area. Incidentally, this number of full-time farmers coincides very closely with the total number of holdings of over 20 acres. We get the important result that the average holding of the full-time farmer is 98.6 acres of crops and grass. The Farm Survey considered 10 acres of rough grazing as equivalent to one acre of improved grass, so that if the 5,600,000 acres of rough grazing were included we find that an "average" full-time farm in England and Wales is just over 100 adjusted acres. Thus over a typical stretch of, say, the Midlands of England, where nearly all the land is cultivated, there would be an average of rather over six farms per square mile worked as full-time holdings. Despite the many other changes which have taken place in British farming, there is abundant evidence to show that this position has not materially changed over the past eighty years. The number of holdings over 20 acres has remained almost constant (the drop from 212,041 in 1885 to 206,373 in 1945 is easily explained by diminution in total farmed area) and, contrary to popular belief, there has been no tendency to consolidate holdings into large units of over 300 acres (instead the number has dropped from 16,608 in 1885 to 12,360 in 1945). The "family farm" of 50 to 300 acres has become more firmly established than ever as the predominant unit.

The density of *farmers* per square mile has thus remained virtually unchanged, but their families are smaller than they were. Though the difference in the country is not as great as in the towns, in 1871 the total rural population was 3.76 times the number of males over 21, compared with 3.15 in 1931. Using these multipliers, we get a density of about 24 per square mile of farmers and their families in 1871, compared with about 20 at the present day.

With farm workers the position is completely different. In 1871 there were 675,768 farm workers in England and Wales over 20 years of age. This is an average of rather over 3 per full-time farmer, or one worker per 35 acres of crops and grass, or about 18 per square mile. Using the multiplier of 3.76, we get 68 per square mile of farm workers and their families. We have corresponding figures from the Census of 1931 of 383,359 farm workers, or 1.73 per farmer, or one per 60 acres of crops and grass, or 10 per square mile. This gives a density of about 32 per square mile of farm workers and their families in 1931. Whilst exactly comparable figures are not available for later years, the numbers of adult male workers dropped sharply from 1931 to 1939, and we may be sure that the present density of workers and their families does not exceed 30.

Summarizing, we find the *Primary Rural Population* was:

92 per square mile of cultivated land (crops and grass) in 1871.
50 per square mile of cultivated land (crops and grass) in 1941.

It is more difficult to calculate the *Secondary Rural Population*. A house-to-house survey of a number of rural parishes in Dorset carried out by Mr. Geoffrey Clark shows a Secondary Rural Population rather less than the Primary. This accords closely with the results obtained by Professor Alexander Stevens (1) who, using an entirely different method of calculation, finds the total "landward population" (i.e., Primary plus Secondary Rural) rather less than double the Primary. For two purely rural counties, Huntingdonshire and Brecknockshire, he finds the multiplier is 1.77 and, in his words, "it seems a fair conclusion that if the value (of the multiplier) differs much from 2 for any community, some special reason must be sought, and will be found, to account for the fact".

Using these figures we thus get a normal rural population density not exceeding 100 per square mile of cultivated land in 1941 against one of 180 in 1871. This, it must be noted, is with the *same* number of farms and farmers and a considerably greater output, so that "rural depopulation" is linked with increasing agricultural efficiency.

It is instructive to see the relationship of these figures to the population of a typical English parish. By "typical" we are thinking still of the well-cultivated lowlands where the land is good but not superlative (2 plus 4 of the Land Classification 1 : 625,000 map). With village centres two miles apart, a large number of parishes approximate to 4 square miles or 2,560 acres. We see that the normal rural population at the present day is not likely to exceed 400*, although it was 720 in 1871. Now this has a very important bearing on the provision of social services and notably on educational facilities. I am indebted to my colleague Professor D. V. Glass for providing me with the following figures of school population in rural districts of England and Wales. In 1871, 23.8 per cent of the rural population fell into the age groups 5–14, i.e., of school age, or about 170 children in the parish of 720 souls, and of these about 80 were in the age group 5–9 for the village school. In 1931, 16.9 per cent fell into age groups 5–14, or about 68 in the same parish, and of these only 34 were of age 5–9 for the village school. If it is the policy of the Ministry of Education to eliminate single-teacher schools and to question the efficiency of even two-teacher schools, we seem to be approaching the day when there will be no rural school in the average village. But the same difficulties arise in the provision of other services.

In this address I am concerned to show deficiencies in our basic knowledge rather than to suggest the answers to such problems as the one just exposed, but one cannot help being forced to the conclusion that to maintain the whole social structure of rural Britain we must look to the "adventitious" population—that we should encourage those who wish to live in the country, whether they are actively engaged in work elsewhere or are retired. Their homes need not break up good farms and they must not detract from maximum food production, but to use the Development Charge or Planning consent to prevent their entry may be disastrous. A solution which has been proposed to some of the difficulties is to select "king villages" or "key" villages for development. Whilst this has some obvious points in its favour, it would be disastrous if it led to the decay of the non-selected villages, and might seriously hamper agriculture if workers or their wives and families—quite legitimately—preferred to live in the "king villages" far removed from their work.

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* Incidentally these figures show that it is nonsense to talk about 600 or 1,000 population being a minimum for a "viable" village.

Lack of Knowledge Any such survey as that just outlined inevitably brings out a lack of knowledge of fundamental importance. It also brings out the failure of the specialist to appreciate the problems in another, though closely related, sphere. It often brings out, too, the failure either to apply knowledge already existing or to use the results already obtained by specialist investigators in another sphere. Particularly serious is the gulf between the natural scientist and the professional town and country planner. It is perhaps especially for the geographer, trained to appreciate, to correlate and to synthesize the results obtained in many realms of knowledge, to bridge this gap.

It may be worth while to indicate some of the more serious gaps in knowledge.

A working knowledge of elementary geology always seems to me an essential part of the mental equipment of any educated man, yet the ignorance not only of planners but often, I find, of other scientists is staggeringly abysmal. Failure to appreciate the disposition of economic minerals and the behaviour of underground water are two aspects of this ignorance which must affect the work of the planner. On the other hand, what really matters in a broad study of land use, possibilities of development and improvement of land is the surface geology. Yet over large areas in Britain the drift deposits remain unmapped, whether by amateurs, academic geologists or the Geological Survey. At a time when the working of gravels affects planning as well as agriculture in every county the lack of drift maps in so many areas is indeed a tragedy. Unfortunately we must accuse many geologists of a lack of interest in the economic aspects of their findings. The lithological characters of a gravel are what matter, together with thickness, variability, character of base deposit, and so on, in exploitation. Similarly the lithological characters and chemical composition of the deposits lumped as "Boulder clay" receive scant attention from the geologist.

We must pass over the lack of soil maps and of a comprehensive soil survey—a gap in factual knowledge so obvious as to speak for itself—whilst expressing an appreciation of the valiant efforts of the small band of workers in this field. Even here there is some lack of co-operation. The modern emphasis on the profile has tended to make some soil work less valuable to the agriculturist, who is concerned so largely with texture, than the older work such as that of our President, Sir John Russell, on the soils of Kent, Surrey and Sussex. Some soil scientists have contended that their work is purely objective and that the determination of a soil series does not give any indication of land quality. On the other hand, other soil scientists claim that their survey gives the whole answer to the problem of land classification.

A great need in this country is a comprehensive survey of water resources. For many years Captain W. N. McClean urged in vain before this Association the need for his pioneer work in river gauging to be continued and extended, and the present position in Britain remains chaotic—the criss-crossing of long distance supply lines; the ever-present threat to fertile farm lands suggested for reservoirs, whether by London or Leicester; and elsewhere, in strange contrast, the continued struggle to send water ever more easily and rapidly to the sea.

In meteorology and climatology the gaps in knowledge are especially in the realm of microclimatology. We know, empirically, that there are certain areas, often small, which are especially favoured by some such factor as free drainage of cold air in spring or a certain combination of slope, aspect, soil type and insolation and ought in any planning of land use to be reserved for agriculture, but there have been few exact surveys to help

the planner. Similarly the fact that the instruments in a Stevenson screen (over grass) are at such a height from the ground as to be *above* the level of growing crops and *below* the level of ripening tree-fruits, leaves an enormous field of detailed observation still needed by the agriculturist and so in the planning of land use.

Those concerned with the planning of land use are often puzzled by the attitude of the ecologist to a primary vegetation survey. The natural or semi-natural vegetation of those great problem lands of the country, the moorlands, heathlands and rough pastures, is said to indicate faithfully the sum total effect of environmental factors as stabilized by human activities, such as controlled grazing, yet no detailed maps are available in most areas.

I do not regard these indications of gaps in basic knowledge as more than samples: they are not given in any critical spirit of the work of the specialists in the field concerned but rather to indicate how, at present, the work of land use planning must rest on a scientifically unsatisfactory basis.

Survey of Existing Land Use It always seems to me obvious that the existing position must be the starting point for any future development. We must start from where we are. This was the basis of the work of the Land Utilisation Survey of Britain carried out in the years 1930–39 (mainly 1931–32), which aimed to record the then existing use of every acre of England, Wales and Scotland (and has since been extended to Northern Ireland). Land use in an old-settled country, such as Britain, is the result of many centuries of trial and error and of the interaction of many factors—natural or geographical, historical and economic. Existing land use has therefore a far deeper significance and is worthy of correspondingly more intensive study than in one of the newer countries of the world. Some of my scientific colleagues have urged that, before surveys of land use or any attempts at land classification are made, the *object* of the work should be known. I disagree. A survey of land use should be strictly objective and the results should be studied objectively. In the Land Utilisation Survey of Britain this has been done at length in the County Reports(1) and in my own summary(2), but three points may be emphasized.

In the first place, such a survey is a snapshot picture in a long process of evolution, and it is important to trace the history of land use. Cartographic comparison brings out the weakness of statistical comparison: the former tended to emphasize the remarkable stability over long periods of years of the land use pattern, contrary to the large changes suggested by the latter. Remarkably little change on the poorest lands and the best lands, the maximum of change on land of intermediate quality is the answer to the apparent contradiction.

In the second place, we may stress the importance of correlation—with solid and drift geology, relief, soils, and climate—which brings out the *increasing* influence of the geographical factors. This is a point I first emphasized at the Nottingham meeting of this Association as being contrary to accepted ideas. In general, with increase of facilities for transport and the development of world trade, geographical conditions must be favourable to secure economic development of land use—as in the cultivation of some specific crop against competition from elsewhere.

In the third place, the separation of the influence of the various geographical, historical and economic factors and the recognition of their continuing influence suggest trends in development. Land use planning becomes, in effect, the encouragement of trends deemed desirable and the conscious attempt to reverse those considered undesirable.

Land Classification In the preceding sections we have talked about an "average" farm on "average" land. Actually few if any countries of comparable size can boast such a wide range as can Britain in scenery or type and quality of land. We may claim that some of our brickearth soils are unsurpassed in natural qualities by any in the world and that this, combined with a climate which for certain purposes is also unrivalled, gives a level of production of a very high order. Such soils are strictly limited in extent and correspondingly precious. Unfortunately some professional town planners have such a pathetically touching belief in the powers of science and scientists that they believe almost any land can be treated and upgraded to this level and that they are free therefore to ignore quality of land. When the Government declared its intention of conserving good agricultural land it became suddenly necessary not only to define different types of land but also to map them. The simple classification into ten types which was developed has been the subject of much discussion which I have published elsewhere in full (3). Although Types 1 to 4 inclusive are the "good" agricultural lands, it must be emphasized that the ten are *types* and that it is not a question of No. 1 the best, and No. 10 the poorest. For certain purposes No. 1 is first class, for other purposes No. 3. For the sake of completeness Table 1 is included to show the area each type covers in England, Wales and Scotland.

This scheme of land classification has more than once been misrepresented. It is based essentially on the *unalterable* factors of elevation, slope, aspect, subsoil and drainage of the land and on the depth, profile and texture of the soil. There are some town planners who will not recognize the permanence of these factors and talk loosely about improving or upgrading land as if large areas could be transferred from one category to another. By lowering the water-table, land can be transformed from Type 3 to Type 1; light soils may be marled and heavy soils lightened by extensive dressing of sand, lime, etc.; but broadly speaking, any upgrading is an improvement of fertility status or productive capacity within the type.

Although in such an old-settled land as Britain there is an obvious correlation between land type and land use, it must be emphasized that the classification is not one based on *actual* land use but is related to potential use.

Apart from this correlation with land use, some interesting comparisons can be made with other types of distribution. The Land Classification map obviously reflects closely the major relief of the land and the solid geology. Other features are associated with such adverse hydrological conditions as bad drainage on peneplaned surfaces and excessive rainfall. But there is also a close tie-up with Types of Farming as shown on the map prepared by the economists of the Ministry of Agriculture.

Many data of immense interest were collected by the 1941 Farm Survey. The results have been analysed statistically, but only to a limited extent geographically. As part of the work of the Survey, the bounds of every farm were recorded on 25-inch, 12½-inch, or 6-inch maps. To transfer these boundaries to smaller scale maps is a colossal task, but where it has been done* the results are interesting in the extreme. Around nearly every village one finds smallholdings and little patches of accommodation land, but in the open country the farms worked by full-time farmers reflect almost everywhere the quality of the land. The poorer the land, the larger the holding needed for the family farmer to make a living. On the finest market-gardening soils of Evesham 10 or even 8 acres are enough

* By the Agricultural Land Service of the Ministry of Agriculture—at present confidential.

TABLE 1. CLASSIFICATION OF LAND IN GREAT BRITAIN

Type of Land	England and Wales		Scotland		Great Britain	
	Acreage	Percentage	Acreage	Percentage	Acreage	Percentage
Major Category I—Good	**17,845,900**	**47.9**	**3,963,300**	**20.8**	**21,809,200**	**38.7**
1. First class	1,963,100	5.3	396,800	2.1	2,359,900	4.2
2. Good general purpose farmland:						
2 (A). Suitable for ploughing	7,065,600	18.9	1,735,900	9.1	8,801,500	15.6
2 (AG). Crops or grass	2,636,900	7.1	192,900	1.0	2,829,800	5.0
3. First class, restricted use unsuitable for ploughing	1,234,800	3.3	8,700	0.0	1,243,500	2.2
4. Good but heavy land	4,945,500	13.3	1,629,000	8.6	6,574,500	11.7
Major Category II—Medium	**11,933,800**	**32.0**	**2,877,400**	**15.1**	**14,811,200**	**26.3**
5. Medium light land:						
5 (A). Suitable for ploughing	2,402,100	6.4	77,400	0.4	2,479,500	4.4
5 (G). Unsuitable for ploughing	220,300	0.6	300	0.0	220,600	0.4
6. Medium general purpose farmland	9,311,400	25.0	2,799,700	14.7	12,111,100	21.5
Major Category III—Poor	**6,350,900**	**17.0**	**12,113,800**	**63.5**	**18,464,700**	**32.8**
7. Poor heavy land	825,900	2.2	54,100	0.3	880,000	1.6
8. Poor mountain and moorland	4,516,800	12.1	12,001,700	62.9	16,518,500	29.3
9. Poor light land	811,800	2.2	57,900	0.3	869,700	1.5
10. Poorest land	196,400	0.5	100	0.0	196,500	0.4
Residue—closely built over	**1,142,700**	**3.1**	**114,200**	**0.6**	**1,256,900**	**2.2**
Total	**37,273,300**	**100.0**	**19,068,700**	**100.0**	**56,342,000**	**100.0**

The figures for England and Wales include the Isle of Man.

for a full-time holding, and where the holdings are large on such land they are either worked far below the level of their capacity or adequately with the aid of a large labour force. At the other extreme in the Welsh uplands the place of the standard 100-acre farm is taken by one of 10 acres of crops and grass with 900 acres of rough grazing. This "carrying capacity" of land is also linked up with the size of parishes. Obviously there are many exceptions, but in general the poorer the land the larger the parish, so that the parish populations in the very large scattered communities often approximate to figures already given. In such cases distance between settlements is an added difficulty in rural planning.

Data have been accumulated, but not yet worked out, showing a linkage between farm rentals and land quality. But, as I have indicated elsewhere, the correlation is not a simple or direct one(3).

The Land Classification map of Britain obviously gives but a crude and highly generalized picture. But it *does* serve to indicate the small extent of the good lands and points to the tracts which should be avoided in the siting of new towns if the country's productive capacity is not to be impaired. In more detail the application and refinement of this method is being used to indicate the directions in which a given town may expand with least damage to productive capacity.

It will be noted that I use the words "productive capacity" and not production. So many town planners insist on using only existing production from what may be a badly farmed area to minimize their estimate of loss incurred by the schemes of urban expansion they may be advocating. Thus 50 acres of well-managed land of Type 3 will support a dairy herd of fifteen 1,000-gallon cows, giving a yield of 30,000 gallons a year per 100 acres. This is not the actual yield of the 1,243,500 acres of Type 3 land shown on the map, but if we are minded to indulge in calculation and speculation we can gain a glimpse of the country's productive capacity.

Two Settlement Patterns Britain has two distinct settlement patterns one imposed on another. The firmly entrenched rural social structure of landlord, tenant-farmer, and farm worker persists despite the increase in numbers of owner-occupiers and the waning fortunes of the harassed landowner. It has resulted in the extremely widespread pattern of "average" farms with farmsteads conveniently placed for each holding and so scattered. Some of the farms have tied cottages for workers, but the remaining population of the parish is grouped in one nucleus (nucleated village) or several (hamlets). The squire's house (if with a large park usually on the poorest land), the church, rectory, inn and stores form the basis of the village, together with the cottages of the agricultural workers and secondary rural population. Where water supply is a problem or defence formerly was, the farmsteads themselves may be in the village. A group of villages needed a market, hence the market towns originally so spaced as to be within reach on foot for man and beast. The development of roads and improved transport at once explain the growth of the better placed market towns and the decay of the remainder. Our medieval ancestors were wise: they knew their sustenance came from the soil and they did not cover valuable land with buildings. Thus the early manufacturing towns, supplying the needs of the countryside, often grew up, as Birmingham did, on tracts of unproductive land.

Superimposed on this still existing rural pattern is the pattern of modern industrial-commercial Britain. In the great growth following the Industrial Revolution the urban spread was mainly on the coalfields and for the greater part on poor land—Sheffield, Leeds–Bradford, Manchester with

TABLE 2. POSSIBLE CHANGES IN LAND USE IN GREAT BRITAIN

Pre-war Land Use			Possible Change	New Percentage		New Acreage	Use
Acreage	Use	Percentage					
1,000,000	Arable—intensive (market gardening)	2.0	→No change	2.0	5.0	2,820,000	Arable—intensive
			→Arable—intensive	3.0			
11,069,400	Arable—farm crops	20.0	→Arable—farm crops	14.5	27.5	15,500,000	Arable—farm crops
			→Orchards and fruit	1.0			
261,300	Orchards and fruit	0.5	→No change	0.5	1.5	845,000	Orchards and fruit
18,897,500	Permanent grassland	33.0	→Arable—farm crops	10.0			
			→Grassland	22.0			
			→Arable—farm crops	3.0	25.0	14,100,000	Grassland
			→Grassland	3.0			
18,775,200	Heathland, moorland and rough grazing	33.0	→No change—rough grazing, sporting, national parks	15.0	15.0	8,450,000	Heathland, moorland, rough grazing
			→Forest and woodland	10.0			
3,219,200	Forest and woodland	6.0					
	High forest (3.0)		→No change	4.0	16.0	9,000,000	Forest and woodland
	Coppice (1.0)		→Coppice	1.0			
	Scrub and uneconomic (2.0)		→Uneconomic	1.0			
1,719,900	Houses with gardens including allotments	3.0		6.0	6.0	3,380,000	Houses with gardens
1,399,200	Land agriculturally unproductive, including airfields, training grounds, etc.	2.5		4.0	4.0	2,246,700	
56,341,700		100.0		100.0	100.0	56,341,700	

The acreages on the left are those calculated from the Land Utilisation maps, and include ponds and other small areas of inland water. Figures include the Isle of Man.

Ashton, Bolton, Bury, Rochdale, the Black Country and the Welsh valleys are all good examples. Though the working of the deeper parts of the coalfields affected good land, it is the partial emancipation of industry from the coalfields by use of electricity which has provided a major threat to the continued existence of the best food-producing lands. This threat is reinforced by the timidity of town planners or parsimony of central and local authorities in seeking level or near level sites. It seems to be accepted far too widely that a satisfactory new town or housing estate depends primarily on more space, ignoring the fact that the majority of our beautiful towns and cities owe much to an intelligent use of varied, often difficult, natural sites.

The two settlement patterns are superimposed rather than fused and the question arises: how far are their established features permanent?

It has already been pointed out there has been remarkably little change over the past eighty years in numbers of farms and consequently of their size. Are changes likely in the foreseeable future? Since it seems that the world trend in farming is towards the British model of the mixed family farm, cultivation-machinery is more likely to be adapted to British needs than British farms reorganized to use large-scale American machinery designed for the already obsolescent prairie type of monoculture. If adjoining British farms are more economically worked as larger units, redundant farmhouses will become country residences or homes for foremen. But any such tendency to amalgamation is offset by the deliberate creation of statutory smallholdings on which selected nominees can learn the business of farming. The suggestion therefore is that the overall rural pattern will remain.

Except for certain areas of land reclamation such as around the Wash or areas marked out for specialized agricultural development such as Romney Marsh, it should be noted that the rural pattern is complete over the country. Farms may be realigned, villages strengthened by additional cottages, market towns revivified by industry, but there is no room for new villages or new towns as part of the rural pattern.

Not so the urban pattern. Seemingly oblivious to the fact that the land area is fixed and inextensible at 37 million acres for England and Wales and 19 million for Scotland—if we ignore small extensions possible by expensive reclamation of tidal flats—demands upon land become ever more extravagant. In place of the Victorian industrial towns with 64 houses to the acre, town planners now demand an acre for 8 or 10 houses. The standards for the new towns, taken over all, are one acre per ten *persons*, so that 6,000 acres are demanded for a town planned for 60,000. In 1925 one-tenth of the surface of England and Wales, according to the Scott Report, was "developed" for towns, villages, roads, etc. *The Times* has calculated that if the present trend continues 15 per cent will be so used by 1962 or 1967. Since towns cannot be built on mountain tops it becomes more realist if we say this is nearly a quarter of all the farmland of the country. In the words of Lord Radnor, we seem to be heading for "new towns to starve in," for we must remember that every 1,000 acres of average land taken robs 1,790 people of their share in the food-producing land of the home country.

If we turn back to the Table of land classification we see that land of medium and poor quality covers more than half the country and that, avoiding the obviously unsuitable areas, there is room both for the proper re-housing of our people and the maintenance of home food production—or at least the conservation of the land for that purpose. I see no reason to revise seriously a calculation I made some years ago of actual and potential use of the land of Britain (Table 2).

But this is a glimpse of speculation into the future, and my main aim in this address has been to appeal for a detached scientific approach to the work of the planning of land use.

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NEW SWEET CORN FROM AMERICA

GORDON HASKELL

John Innes Horticultural Institution, Merton Park

THE demand for early sweet corn of good quality to supplement ordinary vegetables is steadily increasing in England, though ten years ago its use was quite a novelty. Nowadays, many of the better class greengrocers stock it during the summer months, and some of the larger hotels place contracts for the delivery of fresh sweet corn ears.

In this country we require strains that have good germinating ability in the early spring and which come to early harvest ; they must also give high yields of marketable ears. For the last ten years, plant breeders, although often interrupted by war-time problems, have been attempting to improve the sweet corn plant with these aims in view.

Obtaining New Strains Through a grant from the Agricultural Research Council, the writer was able recently to spend a year in the U.S.A. studying the latest maize and sweet corn breeding methods. Visits were made to various states to consult plant breeders about the most suitable varieties to bring back to England for testing under our conditions.

After a careful study of the many strains, during which English climatic conditions were kept in mind, several hundred were brought back. Nearly all were of the yellow-seeded types, as white sweet corn is no longer used in America. The strains were of two genetic kinds : (1) open-pollinated varieties which had been selected by American commercial plant breeders primarily for early maturity and production of quality ears, and (2) hybrids which have been bred both by commercial firms and by geneticists at the State and Federal Experiment Stations for earliness and uniformity of plant and ear characters and high yield.

Hybrid sweet corns differ from open-pollinated varieties not only in the way they have been bred but also in their comparative uniformity. By artificially self-pollinating sweet corn, generations are obtained which are much depressed compared with the variety from which they were obtained. Yet from careful selection of these "inbred lines" breeders have obtained some that are strong enough to use as parents. The plants within each inbred line are remarkably uniform. Inbreds of different maturity can be so obtained, some very early, some medium early and some late. When certain

inbreds are pollinated by other inbreds derived from different open-pollinated varieties, hybrid seed is obtained, and plants from these show good hybrid vigour. By selecting out and cross-pollinating the combinations of two inbreds most suitable for particular purposes, American breeders have been able to raise a wide range of vigorous hybrid sweet corns of different seasonal maturity and for different markets. There is also a range to satisfy the market growers who like to have a choice of strain.

Variety Trial at Merton, 1948 In 1948 an experimental plot was laid down at Merton, but the area available enabled us to test only 80 strains. Reduction to this number meant that strains included in the trial were ruthlessly selected on the basis of their record in North America. This explains why some varieties already known in England, e.g., Golden Sunrise, are absent from the Table. Three strains previously grown and found suitable for English conditions were used as controls. These were Extra Early Bantam, John Innes Hybrid No. 1, and Canada Gold. All the seed, except some from research stations, had been dusted with a protectant to keep down fungal attacks. The experimental block was divided into two plots, each consisting of 80 rows running north and south. Forty seeds of each strain were used for each row, except for Commando, Nuetta and a Spancross line (854.3 × 12), of which only twenty seeds were sown singly. Shallow rows were marked out, and on May 13, 1948, two seeds dropped in them at intervals of 1 foot. The seeds were then lightly covered with soil.

The position of a variety in each plot was previously determined by means of randomized tables of numbers so that no preference was given to the position of any variety in either plot. The soil of the experimental plots was a light sandy loam. It had received fertilizers the previous year, and was known to be high in nitrates and phosphates, thus no fertilizers were given during 1948.

When the seedlings had developed their first leaves, they were thinned out to one per "hill," selection being made by removal of those out of line, rather than by roguing weaker seedlings. Damage by frit fly was very severe and records were made of the severity with which each variety was attacked in both plots. In general, some strains like Northern Cross were more resistant to frit fly and showed less signs of damage than others, but none escaped attack completely.

Explanation of the Table The results given in the Table on pp. 413–5 were obtained as follows. The records of each strain from each plot were taken separately and averaged (given in the Table). The rows were carefully observed until they were judged individually to be ready for harvesting. There was only one picking of ears in each row, and they were harvested when the majority of first ears on main stems were at the milky stage. In some strains, ears on the tillers could also be picked. The first strains harvested were the Spancross lines bred by Dr. W. R. Singleton. These were picked on August 30, 1948 ; all other harvest dates in the Table are measured from this date. The strains are presented in order of earliness, since in England earliness is of first importance.

The percentage stand represents the mean number of plants that remained after thinning, but not at maturity, expressed as a percentage of *half* the number of seeds sown ; this is similar to the percentage germination. The mean number of marketable ears per plant and their mean weights, i.e., individual plant yields, were calculated for each strain. The yield per acre in number and weight of marketable ears was then estimated.

Some of the ears picked were not suitable for market. The column showing the proportion of marketable ears to the total number picked gives a general idea of crop uniformity, e.g., 1.0 indicates that all ears were marketable, while 0.5 indicates that only half were. The next column shows the most frequent row number in a sample of ten ears. This is useful to know, since the twelve-rowed strains of sweet corn are preferred for domestic use; eight-rowed types are no longer popular. The quality of the raw ears was determined in the field; often the more tender ears were also the sweeter. At the present stage of sweet corn usage in this country, all were far superior to the flint corns which unfortunately are often sold as sweet corn. Ears picked at the optimum condition and cooked for ten minutes soften considerably, and are thus more tender than when judged raw. The final column in the Table gives some brief comments, made from yield observations, on plant characters, uniformity and resistance to disease.

The Best Hybrids and Varieties Although some of Dr. Singleton's hybrids, involving inbreds C3, C8, and C12, were very early, their estimated yields of marketable ears were low. Extra Early Bantam is still one of the earliest sweet corn strains for this country, and it also yields well in terms of the number of marketable ears per acre. It is followed by (Seneca 60 × C13) and John Innes Hybrid No. 1, both early and higher yielding. If, however, a heavy yielding strain is required, even though maturing rather later, Northern Cross is recommended. It outstripped all others for yield and plant characters, such as uniformity and frit fly resistance; the ears, as shown in the illustration (p. iv of art inset), were of good uniform appearance, but the quality was not so good as strains from Canada. It is hoped to re-test this and other promising hybrids to see whether they can be sown earlier and therefore harvested sooner. The excellent germination of Northern Cross indicated that it might be cold-hardy to English soil conditions.

It will be seen that some of the later varieties do not necessarily produce higher yields of marketable ears, although two unnamed Connecticut hybrids, namely, (C37.30 × 1184) and (C40 × 1184), both yielded well: Golden Security also yielded well, although this was far too late. Golden Cross Bantam, which is the most popular hybrid in the U.S.A., was too late to be satisfactory for use in England. However, some of the very late varieties and hybrids made vigorous uniform plants with good plant characters. Their tissues are sweet and succulent and therefore these plants might be tested to see if they could be used for fodder or silage, like the white horse-tooth maize grown in some parts of England, but in any case dollar scarcity militates against the import of sweet corn at the moment.

It is still too early to say which of the inbreds brought over from America might be grown successfully for hybrid seed in this country. It is likely that only those produced by State Experiment Stations could be used, since those that are copyright by American seed firms would probably not be available unless grown under special licence.

The Table shows for the first time the behaviour over here of a large number of leading strains that had been *carefully chosen for this trial.* It is hoped that importers will modify their stocks to the more satisfactory modern types of sweet corn hybrids when restrictions on seed imports are relaxed.

Thanks are due to all the commercial firms and research workers who so generously provided material for testing in England.

SWEET CORN TRIALS: 1948

Sown on May 13, 1948, at the John Innes Horticultural Institution, Merton Park

Strains: Variety or Hybrid (*)	Source of Seed	Earliness (days after Aug. 3)	Stand	Estimated Yield per Acre		Proportion of Marketable Ears to Total Number Harvested	Most Frequent Seed Row Number on Ears	Raw Ear Quality		Comments
				No. of marketable ears in thousands	Weight of marketable ears in 1000 lb.			Tenderness	Flavour	
			per cent							
*(C3 × C12)	Connecticut A.E.S.	0	80	8.7	8.3	0.7	12	Fair	Fair	Highly recommended.
*(C3.857-38 × C12)	Connecticut A.E.S.	0	90	8.2	9.7	0.6	12	Tough	—	Reasonably uniform.
*(C8 × C12)	Connecticut A.E.S.	4	50	4.4	5.0	0.7	8	—	Fair	Rather irregular; good plants.
*(C3.857-38 × C13)	Connecticut A.E.S.	4	78	3.9	5.4	0.6	12	Tough	Poor	Slightly irregular.
*(854.3 × 12)	Connecticut A.E.S.	5	88	8.2	11.4	0.3	12	Tough	Poor	Uniform; good tall plants.
*Ottawa Hybrid CH_2	Cent. Exp. Farm, Ottawa	5	78	4.9	6.5	0.7	10–12	Tough	—	Poor plants; frit fly damage.
Extra Early Bantam	Harris, N.Y.	7	80	17.4	6.8	0.9	8	Tough	Fair	Good plants; slightly irregular. Recommended.
*(Seneca 60 × C13)	Robson, N.Y.	7	78	14.2	7.9	0.9	10	—	Poor	Rather short plants.
*Sugar and Gold	Eastern States, Mass.	7	78	11.3	8.8	0.8	12	Tough	Poor	Sun-red plants, i.e., reddish leaves.
Golden Rocket	Robson, N.Y.	7	40	7.7	4.6	0.7	12	Soft	Sweet	Plants somewhat irregular.
*Seneca 60 Hybrid	Robson, N.Y.	7	70	7.0	6.4	0.8	8	Tough	Good	Irregular plants.
Sugar Prince	Cent. Exp. Farm, Ottawa	7	55	6.6	6.7	0.7	12	Tough	Poor	Generally poor plants.
Orchid Baby	Will, N.D.	7	55	4.3	1.9	1.0	irreg.	—	Good	Plants too small; useless.
*John Innes Hybrid No. 1	John Innes, Merton	11	83	13.7	8.2	0.9	10	Rather tough	Fair	Good plants; slightly irregular. Recommended.
North Star	Harris, N.Y.	11	85	12.0	9.7	0.7	12	Fair	Fair	Rather irregular, short plants.
*Ottawa Hybrid CH1	Cent. Exp. Farm, Ottawa	11	88	10.9	8.3	0.9	8	Very soft	Poor	Regular, good plants; dark green. Recommended.
Early Saskatchewan	Burgess, Mich.	11	65	6.0	5.6	0.8	8	Tough	Fair	Generally poor.
Early Golden Sweet	Gill, Or.	11	43	0.3	3.2	0.5	irreg.	—	—	Badly damaged by frit fly and smut.
Dorinny	Cent. Exp. Farm, Ottawa	14	50	7.0	3.0	1.0	—	Medium tough	Sweet	Fairly uniform; striped leaves. Too short.
Early Golden Market	Gill, Or.	14	50	6.5	5.6	0.8	10-irreg.	Soft	Very good	Generally poor plants.
*Northern Cross	Harris, N.Y.	15	100	41.4	11.2	0.9	12	Tough	Fair	Highly recommended; uniform.
Alpine Bantam (Flint)	Michael-Leonard, Ill.	15	85	16.5	7.0	0.9	irreg.	Tough	Poor	Not a real sweet corn.
Canada Gold	John Innes, 1943	15	65	14.7	6.6	0.8	8	Tender	Fair	Plants irregular.
*Seneca Dawn Hybrid	Robson, N.Y.	15	50	12.5	6.7	0.8	irreg.	Tough	Poor	Irregular and poor plants.
*Spancross	F. H. Woodruff, Conn.	15	55	12.0	6.0	0.9	12	Tough	Fair	Rather irregular; badly damaged by frit fly.
*Surprise Hybrid	Vaughan, Ill.	15	53	10.3	4.9	0.7	12	Good	Good	Generally poor; attacked by smut.

Continued

Continued

Strains: Variety or Hybrid (*)	Source of Seed	Earliness (days after Aug. 30)	Stand	Estimated Yield per Acre		Proportion of Marketable Ears to Total Number Harvested	Most Frequent Seed Row Number on Ears	Raw Ear Quality		Comments
				No. of marketable ears in thousands	Weight of marketable ears in 1000 lb.			Tenderness	Flavour	
			per cent							
*(Merton 127 × C17-1)	Connecticut A.E.S.	15	60	9.8	7.0	0.8	14	Rather tough	Fair	Regular, good plants.
Alphagold Bantam	Michael-Leonard, Ill.	15	60	7.1	6.5	0.8	12	Tender	Poor	Irregular and weak plants.
Alpha	Ferry-Morse, Mich.	15	43	4.9	3.7	0.7	8	Tough	Poor	Poor plants and ears; segregates white seed.
*Goldban	Cent. Exp. Farm, Ottawa	15	40	4.4	2.4	0.8	8	Delicate	Very sweet	Irregular, small plants.
*Seneca Golden Hybrid	Robson, N.Y.	18	85	19.6	9.3	0.7	12	Tender	Sweet	Slightly irregular plants; fasciated tips on some ears.
Earliest Golden	Burgess, Mich.	18	88	17.9	11.0	0.8	12	Tough	Sweet	Plants irregular.
*Cornelis' Goldrush Hybrid	Park, S.C.	18	78	17.9	10.4	0.8	12	Tough	Fair	Plants irregular.
*(Merton 127 × Golden Midget)	Connecticut A.E.S.	18	95	15.3	10.5	1.0	12	—	Fair	Uniform, good plants and ears.
*(C40 × C17-1)	Connecticut A.E.S.	18	85	14.1	8.3	0.7	12	Very fair	Fair	Slightly irregular plants.
*Hybrid Golden Hummer	Michael-Leonard, Ill.	18	65	13.0	6.5	0.6	12	Tough	Poor	Fairly uniform and short plants. Good ears.
Earliest Golden	Vaughan, Ill.	18	70	11.8	9.4	0.9	10	—	Sweet	Irregular, small, bushy plants.
Commando	Will, N.D.	18	95	9.7	10.4	1.0	10	Fairly soft	Distinctive taste	Generally very poor plants and ears.
*Our Choice Hybrid	Vaughan, Ill.	21	83	19.6	9.9	0.9	12	Tough	Poor	Irregular plants; good ears.
*Marcross	F. H. Woodruff, Conn.	21	68	11.6	8.0	0.5	12	Tough	Fair	Good, fairly uniform plants; rather short. Good ears.
*Midgolden Hybrid	F. H. Woodruff, Conn.	22	85	14.6	9.5	0.5	10	Tender	Fair	Irregular plants; good ears.
New Golden Gem	Shumway, Ill.	22	63	12.0	7.1	0.7	12	Medium tender	Poor	Plants generally small and irregular.
*60-Day Yellow Hybrid	Buist, Pa.	22	68	9.3	8.2	0.7	12	Tough	Poor	Uniform plants; good ears.
60-Day Early Yellow V.	Buist, Pa.	22	55	8.7	6.0	0.6	12	Tough	Fair	Plants short and irregular. Some smutty ears.
*Carmel Cross	F. H. Woodruff, Conn.	25	75	20.1	9.3	0.6	12	Tough	Sweet	Irregular plants; good ears.
*Wisconsin 801B	Wisconsin, A.E.S.	25	88	16.6	7.4	0.8	8	Medium tender	Fair	Fairly uniform, tall plants; sun-red leaves.
The Burpee	Burpee, Pa.	25	80	16.4	10.4	0.7	12	Tough	Fair	Irregular plants; some ears abnormal.
*Mohican Gold Hybrid	Tristate, Pa.	25	75	8.7	10.1	0.4	12–14	Tough	Fair	Irregular plants; very long ears.
Golden 60-Day	Vaughan, Ill.	25	53	7.1	5.3	0.7	12	—	—	Rather short, irregular plants; short ears.
*Dorick Hybrid	Cent. Exp. Farm, Ottawa	25	60	6.0	6.4	0.5	—	Very tender	—	Small, irregular plants.
Nuetta	Will, N.D.	25	65	4.4	6.8	0.3	irreg.	—	—	Very poor plants and ears.
Early June	Will, N.D.	27	65	3.4	5.6	0.7	—	—	—	Very irregular plants.
*(C37.30 × 1184)	Connecticut, A.E.S.	28	88	27.9	8.7	0.7	irreg.	Tough	Fair	Irregular plants; some ears poorly pollinated.

*(C40 × 1184)	Connecticut, A.E.S.	28	70	26.7	7.9	0.7	12	Fairly soft	Fair	Uniform good plants.
*New Earligold Hybrid	F. H. Woodruff, Conn.	28	83	19.1	10.3	0.8	12	Medium tender	Poor	Irregular plants.
*Honey Cross	Stumpp and Water, N.Y.	28	80	18.0	9.2	0.8	12	Medium tender	Good	Irregular plants.
*Wisconsin 802D	Wisconsin, A.E.S.	28	83	15.8	8.8	0.7	8	Tender	Poor	Irregular plants.
*(1040 × C35)	Connecticut, A.E.S.	28	43	15.3	3.7	0.6	12	Very tender	Fair	Uniform, nice plants; leaves red; nice ears.
*Minhybrid 202	Farmer, Minn.	28	70	14.5	6.4	0.7	8	Tough	Fair	Irregular plants, nicely shaped ears.
*Sunlite Hybrid	Henderson, N.Y.	28	40	6.5	4.2	0.9	12	Tough	Poor	Irregular plants.
Golden Hummer V.	Michael-Leonard, Ill.	28	30	5.4	3.9	0.7	12	Tough	Poor	Irregular, poor plants.
Extra Early Golden	Comstock, Conn.	29	48	6.5	6.0	0.6	10–12–14	Tough	Poor	Highly irregular.
Tendermost	Gill, Or.	39	63	13.6	8.1	0.7	14	Medium tender	Fair	Short plants; good ears.
Tendergold	Michael-Leonard, Ill.	39	60	12.6	7.3	0.6	12	Tough	Fair	Fairly uniform plants.
*Improved Sencross	F. H. Woodruff, Conn.	40	93	26.2	12.2	0.7	12	Medium tough	Poor	Rather irregular plants; good ears.
Charlevoix	Ferry-Morse, Mich.	40	48	12.0	5.1	0.7	8–12–14	Fairly tender	Sweet	Good plants; good ears.
Golden Security	F. H. Woodruff, Conn.	50	95	35.4	10.8	0.8	14	Tough	Fair	Uniform plants and ears; perhaps useful for silage.
*Golden Cross Bantam	Robson, N.Y.	51	70	28.2	8.4	0.7	12	—	—	Uniform, dark green plants; good ears. ? for silage.
Iroquois Golden	Tristate, Pa.	51	95	26.7	6.5	0.7	16	Very tough	Fair	Large, uniform plants and ears; useful for silage.
*Cream of Gold Hybrid	Henderson, N.Y.	51	78	24.0	8.2	0.8	8	Tender	Sweet	Very large, tall, regular plants; good ears. ? for silage.
*Pioneer Hybrid	Pioneer Iowa	51	80	21.3	10.2	0.8	12	Medium tough	—	Perhaps useful as silage.
*Wisconsin 803	Wisconsin, A.E.S.	51	70	19.7	8.0	0.8	8	Tender	Sweet	Sturdy plants.
*Wisconsin 800A	Wisconsin, A.E.S.	51	73	18.5	7.3	0.9	8	Tender	Poor	Produces many tillers.
*(Seneca 92 × 28)	Robson, N.Y.	51	78	17.4	9.1	0.7	12	Tough	Poor	Uniform plants, perhaps useful as silage.
*Wisconsin 804C	Wisconsin, A.E.S.	51	50	17.4	5.3	0.7	10	Medium tender	Poor	Uniform, rather short plants; uniform ears.
Barden's Wonder Bantam	Michael-Leonard, Ill.	51	55	7.1	6.7	0.6	8	Tender	Fair	Plants and ears irregular.
*Snowcross (White)	Burpee, Pa.	51	53	15.2	6.1	0.5	14	Tough	Poor	White seeded. ? for silage.
Pickaninny	Cent. Exp. Farm, Ottawa	—	—	0	0	—	—	—	—	Yellow seeds, turn purple when ripe.
Mason's Golden Midget	Kennedy, N.Y.	—	—	0	0	—	—	—	—	Too small for commercial use.
*Earliest Pioneer Hybrid	Will, N.D.	—	—	0	0	—	—	—	—	All plants dwarf and smutty.

Strains underlined were used as controls. Those with asterisks are hybrids; the rest are varieties.

The assistance of Miss P. Dow in preparing this table is acknowledged.

SHEEP-GRAZING OF SEAWEED

OBSERVATIONS ON NORTH RONALDSHAY, ORKNEY IS.

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SEAWEED has long been used in many countries as a stock food. It has been reported that it is readily grazed by livestock in many northern European countries, in Lapland, and in the Faroe Islands (1). In an essay published in 1874, Pringle (2) included some notes on the management of the Orkney breed of sheep, which, he said, were kept on North Ronaldshay and fed on seaweed "of which they were very fond". In 1939 Scarth and Watt (3), when describing agricultural conditions in the Orkney Islands, again reported the consumption of seaweed by these sheep, which are still kept on the perimeter of North Ronaldshay, the most northerly isle of the Orkney group. They also pointed out that seaweed is eaten on the shores of Eynhallow, between Evie Parish and Rousay, where the sheep regularly seek the beach at ebb-tide, no matter how rich the grazing on land may be. This is not confined to the native breed, for Cheviots, put out on such islands for the summer, are observed eating seaweed within a few days of arrival.

Hendrick (4) was more detailed in his observations, made in the west of Lewis, the Hebridean island, and noticed that both cattle and sheep eat seaweed very readily, but that they are selective both in the species eaten and in the parts of an individual species eaten. Hercus (5) reported that sheep in South Otago show "a remarkable craving for seaweed," and suggested that this may be attributed to an iodine deficiency in their normal diet. Moore (6) has testified to the health of sheep and pigs which graze seaweed in New Zealand. When possible, sheep eat seaweed regularly and afterwards appear to be "bright and lively, and are generally in excellent condition".

However, although information has been collected in a variety of accurate laboratory trials concerning the extent to which seaweed, in the form of a dried meal, may be fed to the various classes of domestic stock (1, 7, 8, 9), very little is known of the circumstances accompanying the grazing by stock of seaweed in its natural environment. Only evidence of an anecdotal character has, so far, recorded the conditions surrounding the grazing of seaweed on the seashore, and even this is severely limited in quantity. It is clear that there is still much information required concerning the seaweed species and parts of species actually eaten by various classes of livestock and, also, the general condition of health of animals eating seaweed. A visit was therefore made to North Ronaldshay in the winter of 1948–49, and the following information is the result of repeated observations of the sheep's feeding habits at high- and low-tides, and of many discussions with local crofters.

Management, Breed, and Health of Sheep Before discussing in detail the species of seaweed eaten, it is necessary to describe briefly the type of sheep concerned, and the conditions of their management. A detailed description of the sheep husbandry has already been given (10).

Around the twelve-mile perimeter of the Island runs a dry stone dyke between six and eight feet high. With the exception of the first two months of lactation, the two thousand sheep are always kept on the outside of this barrier. During the initial stages of lactation, most of the ewes and lambs are folded or tethered on inland pastures, but, even at this time, an occasional ewe and lamb remains on the shore. Outside the stone dyke lies the foreshore, with its associated strips of permanent pasture. In 1874, however, Pringle ([2]) describes these pastures as "strips of waste land," and it is quite fair to say that the quantity of grass available from these sources could not appreciably affect the animals' diet. There was literally no grass available while we were on the Island, and we were assured that even in spring the amount is negligible; sheep patronize the patches only when an exceptionally high tide submerges other more popular parts of the shore. It is no exaggeration to say that the sheep are dependent on the seaweed for all their nutritional requirements.

The animals are never short of food. In the summer, ebb-tides expose acres of seaweed-covered rocks, and in the winter the storms wash the plants ashore by the ton. Probably these are the only sheep in Scotland which are better fed in winter than in summer. Since their food becomes available in greatest quantities during the winter storms, these sheep reach prime condition in December, and those slaughtered in winter give fat, well-balanced carcasses.

All the sheep belong to the native Orkney breed, which is probably the smallest and hardiest in Britain. An animal takes from three to four years to reach maturity, and even at this age an average wether gives a carcass weight of only 30 lb. The meat of these animals is darker than normal, and has a characteristic, but by no means unpleasant, flavour. The wool is said by the manufacturers to be warmer than any other, but the annual yield per animal is only two or three pounds. In trying to obtain bigger yields of meat and wool, crosses have been made between the Orkney ewes and Cheviot, Blackface, Border Leicester, and even Shetland, rams. None of these has been successful, however, since the resulting animals were unable to withstand successfully the exposure and rigours of the North Ronaldshay foreshore.

Although the mortality rate amongst these sheep is not low, the general health of the animals is excellent, the great proportion of the deaths being caused by drowning and exposure. Braxy is very uncommon; there are only isolated cases of gid, ticks are entirely absent, and there are few intestinal worms. Foot rot is never troublesome and, on the diet of seaweed there is no bloat. Scab is unknown, and in view of the peculiar circumstances of the Island, the dipping regulations have been waived.

Zoning of Seaweed Species The seaweed itself is distributed in the usual zones along the rocky shore. Along the upper limit of the high-tide mark the rocks are covered with a dense turf of Channelled Wrack (*Pelvetia canaliculata*) and Flat Wrack (*Fucus spiralis*). According to figures quoted by Wilson ([11])*, the plants at the top of this belt are exposed to the air for 80 or 90 per cent of the time, and at the bottom for 60 or 70 per cent. Below this belt is a broad zone consisting of Knotted Wrack (*Ascophyllum nodosum*) and Bladder Wrack (*Fucus vesiculosus*), which are present in very large quantities, and are exposed from 15 to 55 per cent of the time. At their lowest level they overlap another broad zone consisting of Serrated Wrack (*Fucus serratus*); this is

* In this connection this authority will be quoted throughout.

exposed in particularly large quantities at the spring low tides, and receives from 0 to 50 per cent exposure. Below this come the various species of the order *Laminariales*, which are exposed only at the very low tides, and then only for a short time. To this zonal distribution of growth, however, must be added the great stretch of shore above the high-tide mark which is covered by the hundreds of tons of tangle that are washed up every year by the storms. In some places this material lies as much as six feet thick and extends for two hundred yards along the shore. Its collection for the kelp industry used to be the main occupation of the Island's male population, but now the surplus left by the sheep merely lies rotting on the shore. Almost all of this tangle belongs to the *Laminariales*, the greater proportion being *Lamimaria digitata*.

The species actually available to the animal are, therefore, zoned as follows: *Laminaria* sp., *Pelvetia canaliculata* and *Fucus spiralis*, *Ascophyllum nodosum* and *Fucus vesiculosus*, *Fucus serratus*, and, nearest the water, *Laminaria* sp.

While the *Phaeophyceae* are undoubtedly the most important algae from a nutritional standpoint, there are a few *Chlorophyceae* and *Rhodophyceae* that must be mentioned. Of the green weeds, the only three that occur in appreciable quantities are *Ulva lattuca*, *Cladophora* sp., and *Enteromorpha* sp., which are distributed widely throughout the inter-tidal rock pools. The red weeds are more plentiful, and *Rhodymenia palmatta*, *Chondrus crispus*, *Gigartina mamillosa*, *Corallina officinalis*, and, of course, the *Polysiphonia* sp. that grow in abundance on the *Ascophyllum*, are all available to the sheep. Of these, all are commonly found in the inter-tidal pools, except *Rhodymenia palmatta*, which is seldom found growing except at very low tides; appreciable quantities of it are, however, thrown up on the stipes of the *Laminaria* sp.

Palatability Without a doubt the species most commonly eaten is *L. digitata*. This is surprising in view of the observations of Hendrick (4), who stated that neither sheep nor cattle ever ate it. It is an obvious peculiarity that the sheep prefer to eat the portion of the plant at the junction of the stipe and frond—in fact, just at the point where intercalary growth takes place. After this the complete frond is eaten, and many animals gnaw the stipes, which are often six feet long and as much as two inches in diameter. If the islanders ever have occasion to feed seaweed to an animal off the shore, it is *L. digitata* that they cart inland. Besides this species, *L. stenophylla*, *L. Cloustoni*, *L. saccharina*, and *L. hieroglyphica* are all common on the shore, and all eaten in quite large amounts in the same manner as *L. digitata*. *Alaria esculenta* is not so common as the others, but it is certainly equally popular and eaten on every possible occasion. *Chorda filum* is very scarce and, as far as was seen, is never eaten by the sheep.

Compared with the *Laminariales*, the *Fucales* are definitely unpalatable. The only species that are eaten readily are *Pelvetia canaliculata* and *Fucus spiralis*. The young and more tender branches of *Ascophyllum* and *F. vesiculosus* are nibbled, but these species, like *F. serratus*, are certainly not popular. *Himanthalia lorea* and *Halidrys siliquosa* are very uncommon, and it is doubtful whether they are ever eaten.

The red weeds probably include the most palatable species of all, but since they are not present in very large quantities their dietary significance is small. Dulse (*Rhodymenia palmatta*) is the most palatable of all the weeds, and when washed ashore attached to the stipes of the *Laminaria* sp. it is eagerly nibbled off. Irish or Icelandic Moss (*Chondrus crispus*) comes

next, and this, together with Carragheen (*Gigartina mamillosa*), is eaten at every available opportunity. Both these species, however, occur most commonly in the rock pools exposed at low tide, and the sheep will never put their mouths in the salt water to reach even the most palatable of plants. *Polysiphonia* is the only other red weed that is eaten in appreciable quantities; while nibbling the young shoots of *Ascophyllum*, the sheep will eat the associated *Polysiphonia*, and they were observed to eat this without, at the same time, taking the *Ascophyllum*.

It is worth while noting that there is an apparent correlation between these observations on the palatability of the species and those previously reported on their nutritive values. In 1939 Ringen [9] published the results of a series of seaweed digestibility experiments with sheep and pigs which showed that *Fucus vesiculosus* was less digestible than *Laminaria*. Senior, Collins, and Kelly [7] confirmed this finding in some further digestibility trials with sheep. These workers found that *L. stenophylla* and *L. digitata* were distinctly more digestible than *F. vesiculosus* and *F. serratus*, although only slightly more digestible than *Ascophyllum nodosium*.

From a nutritional aspect the fauna associated with the seaweed must be of importance, and it is probable that a variety of small animals and snails are swallowed daily. On many occasions we saw *Laminaria* fronds being eaten which were covered with the calcareous tubes of *Spirorbis borealis*; these must make a large contribution to the mineral requirements of the sheep.

Summary The Orkney sheep found on North Ronaldshay subsist entirely on seaweed. They are vigorous and healthy animals, and show no clinical symptoms of any nutritional deficiency. Seaweed of the order *Laminariales* forms the bulk of the diet, although a large variety of other red, green and brown weeds are eaten to a much less extent. The most palatable species are: (a) *Rhodymenia palmatta*; (b) *Chondrus crispus* and *Gigartina mamillosa*; (c) *Laminaria digitata*—particularly at the junction of the stipe and frond. The fauna associated with the seaweed are also of nutritional significance.

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RUSHES IN GRASSLAND

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THE presence of rushes in grassland is generally regarded as indicating a faulty or non-existent drainage causing waterlogged conditions. Broadly speaking, this is true, but of recent years the march of the plough into fields that for many generations have been undisturbed by man has shown conclusively that the common rush is a plant which is equally at home on well-drained land, light soils and heavy soils, always provided it is allowed to reign supreme and not subjected to competition. From many points of view it is unfortunate that rushes have been so widely acknowledged as indicators of wet land, for there is little doubt that this has given the impression in many cases that drainage was the first and essential step towards eradication. Because drainage is an expensive operation, little, if any, action has been taken to deal with the invaders, whereas with appropriate cultural treatment they might have been eradicated completely.

Within recent years the question of rush infestation has assumed disturbing proportions. Vast acreages of poor, worn-out grassland were ploughed out for cropping or direct reseeding during the years 1939-45, and a considerable proportion of this having been laid back to grass now carries a rush-dominant sward. Of such magnitude is the problem that a field-to-field survey carried out by the West Riding W.A.E.C. in 1946 (1) showed that in this county alone 10,000 acres of land were badly infested; and of these at least 1,500 acres contained more than 60 per cent of rushes. In other counties the same sort of figures could be obtained. Yet with suitable treatment this grassland could be freed of the intruder in two or three seasons by normal methods of cultivation.

The problem is not new; following the 1914-18 war, farmers in the high rainfall regions of the west experienced the same trouble. Then, however, the affected acreage of land was relatively small and the problem was often accepted as just one of the burdens of war. Today, however, because of the considerable acreage involved, complacency.

The survey referred to above provided direct evidence that in most instances only spasmodic efforts had been made to eradicate the rushes, that fertilizer treatment had been neglected or was inadequate and that cross-cropping had in many cases impoverished the fertility of the soil prior to reseeding. Repeated haying of newly reseeded fields was also a likely contributory factor.

Control by Good Husbandry Few plants surpass the common rush (*Juncus communis*) in its ability to seed and provide a legacy for the future. On an average piece of rushy land no less than 8,000,000 seeds can be produced on a square yard in one season. To add to the difficulties of eradication these seeds can remain viable for upwards of sixty years (2), germinating readily when brought to the surface. Contrary to the general opinion, waterlogged conditions or a high water-table are not essential for the establishment of the seedlings; the only requirement would appear to be that they must not be allowed to dry out. Fortunately, however, rush seedlings are particularly delicate; the least disturbance or mechanical injury is sufficient to kill them, whilst competition from other, more vigorous, seedlings will suppress them to the point of extinction. This is the key to the solution of the problem of rush infestation following the ploughing out of old grassland.

In districts where the common rush has grown profusely for generations, it is reasonable to assume that adjacent land not necessarily showing signs of rushes will nevertheless carry a high content of rush seed in the soil. It may be that the permanent grassland has been cleared of rushes by good management and that the arable land has always carried good crops, so keeping the rush in subjection. Under such circumstances, rushes may develop with a lowering of the standard of farming, e.g., on moist soil of poor fertility and where there is no competitive herbage. Indeed, laboratory and small-scale field trials in Yorkshire have shown this to be so. Good husbandry is the weapon to use in controlling the rush, and when this is assured rushes are not likely to present farmers with any serious problem of eradication, even though the soil teems with seed.

It is not intended to suggest that good drainage is not important ; it is, and under conditions where there is a danger of waterlogging the first step is to rectify the trouble. But from research work and observations in many parts of the country, it appears that the rush is perhaps more an indicator of soil poverty than excessive wetness. Careful attention must be given to the question of liming and fertilizing to ensure that the right conditions are secured to encourage the maximum competition to the growth of rush seedlings. Perhaps the best competition is a grass turf ; if in reseeding a close-knit turf is obtained in the shortest possible time, rush seedlings have little hope of establishing themselves. The following seeds mixture gives promise of fulfilling this requirement when sown in conjunction with adequate fertilizer dressings :

	lb. per acre
Timothy S.48	6
,, S.50	6
Crested dogstail	2
White clover S.100	3
Wild white clover	1
	18

An important point to watch is that where potential rush plants abound, the sward must be *maintained* in a vigorous healthy condition. Far too frequently the initial fertilizer treatment given at seeding time is considered adequate for many years afterwards. Failure to follow up with regular applications of phosphate and potash, ample nitrogen and lime if needed, has in very many cases resulted in a starved, thin sward facilitating the establishment and vigour of rush seedlings. In the West Riding investigation it was evident that this factor accounted in the majority of the cases for the dominance of the rush.

What of the established rushes, those which have been present for so many years that they are now regarded as inevitable ? Can they be eradicated? The work of Mercer (3) and others has indicated that when repeated cutting is allied to sound fertilizing the rushes can be eliminated. The treatment must be continued for a number of years and a close well-grazed sward encouraged. Quite often, cutting three times in one season is justified, and the closer the cut the greater the damage to the rush plants. Cattle will graze on young rush growth, and heavy stocking after mowing is advantageous. Compared with ploughing and reseeding, this method gives comparatively slow control of the rushes, but it has the merit of simplicity and it is cheaper. In hill country many farmers who tackled this problem after ploughing out for the 1914-18 food production campaign have asserted that ten years elapsed before the rushes were finally conquered, but today, with a clearer appreciation of the underlying principles of control, they should be eradicated much quicker.

RUSHES IN GRASSLAND

Rushes may be killed by chemicals, and under certain circumstances this method of control may appeal to farmers. The application of sodium chlorate at 2 cwt. per acre in October will kill all the herbage, and the land can be left bare until the following spring, by which time the toxic effect of the chlorate will be dissipated and orthodox renovation methods can be brought into operation. Alternatively, should this treatment be considered too drastic, MCPA (10 per cent) at 2 gallons per acre kills the rushes without harming the grass, although the clovers may be checked severely. Here again, however, there is no short cut to success, and chemical treatment of the rushes must be supplemented by good grass husbandry to ensure that the rushes are not allowed a further opportunity of gaining supremacy.

To sum up, recent research indicates that the control of rushes in grassland is primarily a husbandry problem, and that when the right soil conditions are allied to the right grazing management to promote the right kind of sward, rushes have little chance of survival. Even long-established rushes can be eliminated, given patience and the will to tackle the job.

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AGRICULTURAL INDEX NUMBER

Monthly Index Numbers of Prices of Agricultural Products Including Government Grants. (Base 1927–29 = 100)

Month	Uncorrected for Seasonal Variation					*Corrected for Seasonal Variation*				
	1939	1946	1947	1948	1949	*1939*	*1946*	*1947*	*1948*	*1949*
January ..	96	199	217	242	245†	*89*	*179*	*193*	*215*	*218†*
February	94	201	211	240	243†	*88*	*182*	*190*	*217*	*219†*
March ..	90	192	201	232	237†	*91*	*183*	*191*	*220*	*225†*
April ..	90	176	186	214	227†	*95*	*182*	*192*	*222*	*237†*
May ..	82	162	171	198	208†	*91*	*181*	*192*	*223*	*235†*
June ..	80	161	170	198	207†	*89*	*181*	*193*	*225*	*236†*
July ..	85	168	181	199†	209†	*93*	*182*	*197*	*217†*	*232†*
August ..	87	176	192	211†	224†	*91*	*191*	*209*	*228†*	*244†*
September	93	177	206	210†	223†	*93*	*188*	*223*	*227†*	*242†*
October ..	97	192	222	225†		*92*	*187*	*216*	*220†*	
November	107	209	235	239†		*98*	*192*	*217*	*232†*	
December	114	214	241	245†		*104*	*192*	*217*	*221†*	

† Provisional.

CONTINUOUS CLOCHES ON COMMERCIAL HOLDINGS

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THE modern continuous cloche was invented in 1912 but, except amongst strawberry growers in Hampshire, its use was for many years confined largely to private gardens. It was not until the beginning of World War II that market growers began to use continuous cloches on an extensive scale. Their interest was aroused principally because of the suddenly increased demand for home-produced salads and other out-of-season produce, owing to the reduction of imports and to the increasing difficulty of obtaining other glass equipment, such as frames and glasshouses. Once both growers and manufacturers turned their attention seriously to the use of cloches under market-garden conditions, cloche cultivation quickly became a sound economic proposition, by reason of attention to such matters as planning, use of machinery and the careful choice and timing of crops.

There is no doubt that cloches have contributed greatly to the food production of the nation during and since the war, and it has been estimated that well over five million are used by amateur and commercial growers at the present time. Now that certain materials are becoming more plentiful and some controls are being taken off, growers contemplating an increase in their glass equipment have a greater choice than hitherto, for, not only are a certain number of glasshouses being built under permit, but Dutch lights made with timber or metal frames, as well as numerous patent frame and so-called cloche structures with metal frameworks, are available in quantity. Nevertheless, continuous cloches are likely to retain their popularity, and since the technique of using cloches differs considerably from that adopted for ordinary frames and glasshouses they cannot strictly be regarded as substitutes for each other.

Features of Continuous Cloches Several different manufactured patterns of continuous cloches are available, but in recent years there has been a tendency for many structures described as cloches to be so wide and tall that they no longer conform to the original type of continuous cloche. The cultural technique and management devised and developed for continuous cloches during the war years was based on certain specific characteristics of such equipment, not shared by many other forms of glass protection for crops. I consider that a typical continuous cloche should have the following characteristics:

1. It should be reasonably rigid, and capable of being carried from place to place as a complete unit without dismantling and reconstruction.
2. A certain amount of ventilation should be permanent and, if possible, provision should be made for increased adjustable ventilation.
3. While providing protection for the growing crops there should, nevertheless, be the minimum obstruction to daylight, both from the roof and sides.
4. It should be sufficiently narrow to permit established plants to derive some benefit from natural rainfall or water applied artificially falling on and around the cloche.

It should be made clear that this is merely an attempt to define a typical continuous cloche and that it is not implied that the above characteristics prove cloches to be superior to frames or other structures. Horticulturists will realize that any structure which conforms to this description will provide a special set of environmental conditions for the crops grown under its protection—conditions which may be expected to differ widely from those obtained in glasshouses and under many types of frames. Structures made with metal frames and glass walls and roofs, but which

are so large that they are not conveniently portable and are too wide for the crops to gain any advantage from outside watering or rainfall, cannot be operated conveniently by the same technique as that used for typical continuous cloches. On the other hand, they are likely to prove more efficient for plant growth than a typical garden-frame with opaque sides or walls and are preferable to cloches for many crops, particularly because of their height. They might almost be called "all-glass portable frames".

The Cloche Holding The choice of a suitable site for the commercial continuous cloche holding is of primary importance. The difficulties to be faced when trying to grow profitable crops on an unfavourably situated holding may be almost insurmountable. Thus if the field lies in a bad frost pocket, or in a very "late" district which by reason of its situation or high altitude has a low average temperature throughout the year, there is little that even the best grower can do to improve matters. It must be remembered that although cloches provide glass protection to the crops, the temperature inside the cloches is influenced by the temperature outside, and, moreover, that many of the crops complete a large part of their life in the open air.

For early work, a district where the annual sunshine figures are high and the climate reasonably mild, such as on the southern coast of England, offers tremendous advantages. The value of long sunlight and daylight hours for glasshouse work has frequently been emphasized, and this is no less true for continuous cloche or frame cultivation. Nevertheless, approaching the other extreme, growers in districts where the sunshine figures are low and rainfall heavy can still use these glass structures advantageously for producing crops which otherwise would almost certainly fail in the open. In some of the cooler districts of England and Scotland cloches are used for growing tomatoes and for starting sweet corn and runner beans.

In any district, a site which is exposed to strong gales or wind-borne sea spray should be avoided. Similarly one with a southern aspect and a slight slope to the south is generally favourable to early production.

A suitable soil is also of considerable importance, although in most cases much improvement can be made by draining, manuring, and liming. Rapid growth and early out-of-season production is the aim of most cloche growers, hence the preference for the lighter sandy loams, which are workable almost all the year round and are well suited to early intensive production.

In common with all other forms of intensive horticulture, manuring, especially with bulky organics, such as farmyard manure and compost, must be very generous. The use of large quantities of other organic manures and fertilizers is also recommended, because cropping is expected to be intensive and heavy, and growth speedy; indeed it is hardly possible for the average grower to apply too much bulky organic material to his land these days. Chemical soil analyses are particularly valuable for ascertaining the lime requirement of the soil and for indicating any marked deficiency of any particular plant food.

Labour Crops grown with the aid of glass protection need more labour than those grown out of doors. There must be sufficient labour to control weeds, for under such intensive conditions they grow rapidly and vigorously.

Adequate labour must also be available for sowing and planting the crops, for pest and disease control, and, above all, for harvesting and marketing to be carried out properly and at the correct times. All the

workers should be interested in their job and, of course, the key men skilled in their craft. Workers moving amongst cloches need to be rather more careful in their movements than where there is no glass.

Where the cloche unit forms only a section of a large market garden, all or most of the work amongst the cloches should be carried out by a separate staff. It may be necessary to bring in outside labour at the peak of tomato picking, but those who work regularly amongst the cloches have no difficulty in avoiding damage to the equipment or themselves.

The movement of cloches from one crop to another becomes quite a simple operation with practice, and workers may be trained to work in pairs for speedy and efficient operation. In general, a cloche unit should be run with a small number of regular workers, who thus become proficient and confident in their work, rather than by bringing in large gangs of inexperienced labour to do a big job quickly at comparatively long intervals.

It is my considered opinion that every cloche grower should endeavour to install some form of irrigation for his crops. Even in the wettest years there is sure to be some occasion when such an installation will enable him to maintain production at a high level. Not only is watering valuable to enable plants to grow during a dry period, but also to make it possible for sowings and plantings to be carried out at the correct time despite drought.

The most widely used system of irrigation is that of overhead spray lines; this lends itself particularly well to cloche cultivation because relatively narrow strips of ground can be watered fairly uniformly. In recent years irrigation by means of rotating jets or rainers watering a circular area has increased in popularity for certain purposes, but, because cloches are normally set out in straight rows and alternate crops are grown on the strip system, it is not convenient to apply the water in this way. Nevertheless, in spite of their shortcomings for cloche work, circular sprayers are certainly much better than no irrigation apparatus at all.

Another form of irrigation which has been introduced comparatively recently is known as automatic trickle irrigation, but I have not had an opportunity of seeing such apparatus in action on cloche crops.

Overhead irrigation normally consists of portable spray lides supported on tripods or stands which can readily be moved to each part of the cloche garden as required. If sufficient capital is available there are many advantages to be gained by installing a system of permanent overhead irrigation, the spray lines being supported on posts about 8 feet above ground level. If the whole cloche garden can be equipped with permanent irrigation in this way the labour and inconvenience of moving the spray lines from place to place is avoided, but few growers are able to contemplate the heavy capital expenditure involved.

Planning the Holding Efficient management of a holding depends very largely upon the planning and lay-out of the crops and cloches. In this connection the length of the cloche rows is important, since excessively long rows increase production costs; for example, the produce is normally collected in containers which may be carried or wheeled on a truck to the end of the cloche row, there to await collection and transport to the packing-shed. If the rows are very long, much time is wasted in conveying the containers to the end of the cloche rows and returning to the picking point.

Another factor in connection with the length of the rows is that of irrigation. If the rows are too long the pressure of water may drop, and if an oscillator is used it may be subjected to great strain or fail to operate. On the other hand, very short rows necessitate moving the pipes on to a

new strip too frequently. As a rough guide it is suggested that the length of the cloche rows should not be more than 100 yards, while on many holdings a length of 50 yards (or even 25) will be found much more convenient. The roadway or headland should be wide enough to permit the passage of a lorry.

Incidentally, in calculating the gross returns from any particular cloche crop it is usual to use a 100-yard run as a basic unit. Such calculations are facilitated if the rows are of standard lengths in units of say, 20, 25, 50 or 100 yards.

The fact that continuous cloches have not only glass roofs but glass sides as well enables light to penetrate readily from above and from the sides on to the plants growing beneath. Nevertheless, the question whether the rows should run north to south or east to west is of some importance, at any rate in some seasons. In the spring of 1949 I noticed a variation in the growth of the lettuce crop produced in adjacent rows of cloches. The rows stretched from east to west and were set out in pairs. The row flanking the southern aspect produced earlier and better heads of lettuces than its neighbour which faced north. This was believed to be due to the effects of sunshine on the southern row, but it must be pointed out that the row facing north would give some protection to its neighbour while itself bearing the brunt of any cold winds coming from that direction.

The summer crops grown in the same cloche garden did not show a similar variation. Until more scientific information is available it is suggested that where a choice is available the rows should run from north to south, as this seems to give satisfactory results throughout the year.

When planning a new cloche section or holding it is necessary to lay out adequate roads, and they should be constructed properly so that they can be used in all weathers. The main water-pipes for irrigation will normally run alongside such roads.

A packing-shed with facilities for washing is essential. Much time and expense will be saved if the site for the packing-shed is chosen carefully and detailed attention given to the planning of the shed itself.

Cultivation Equipment This is an age of mechanization, and most growers using large numbers of cloches find it essential to have some type of mechanical cultivator or tractor. As a rule space limitations make it impossible to use full-sized, four-wheeled tractors, except sometimes after most of the crops have been gathered, when it is often possible to plough comparatively wide strips of land between stacked cloches.

For general cultivation and soil preparation throughout the season, the smaller "walking" tractors are commonly used. Those capable of ploughing are popular and, in general, a one-way plough is the most suitable. Even these, however, have the disadvantage that an open furrow is left at the end of each strip of ploughed land, and for this reason many growers prefer to use one of the rotary cultivators or rotary hoes. On the whole it seems that the combination of mechanical rotary hoeing for the general regular work amongst the cloches, and a modern four-wheeled tractor system with hydraulically operated implements for ploughing as much of the land as possible during the winter, is the best. Alternatively, it may be considered worth while to remove all cloches from the site to the headland every third autumn so that the whole of the land, including the pathways, can be ploughed and cultivated with a large tractor.

Spraying apparatus will be needed on almost every cloche holding. The importance of taking prompt measures to control pests and diseases

is, perhaps, even greater under intensive cultivation involving cloches than it is for open-air market gardening.

Strip Cropping It is probably true to say that the introduction of so-called strip cropping systems secured the acceptance of cloches by growers as practical commercial equipment. The whole principle of strip cropping depends on the movement of one row of cloches sideways to an adjacent strip of land of equivalent area which has either been left vacant for the purpose or has just been cleared of a crop. Normally the cloches are laid out in double rows, but for certain cropping schemes a single row is preferred.

Most cloche growers aim at using the glass to protect as many crops as possible during the year and try to avoid having the cloches idle for any appreciable length of time. The cloches are first used on one strip to cover the first crop of the season, usually during the period from October or January until mid-April. They are then moved to an adjoining strip and remain there protecting the second crop of the season, normally until some time in June. The cloches are then moved either on to a third strip kept vacant for the purpose or back to the first strip if by that time the early spring crop on that strip has been cleared. A typical commercial rotation of crops under cloches is as follows.

From October to April—lettuces;

April to the end of May or early June—tomatoes (plants having been raised in heat);

From June to September—cucumbers or melons.

Flowers also may be grown successfully under cloches. Limitation of space prevents full discussion in this article of the various crops which can be included in these rotations, but much information on the subject is already available. It will be realized that when crops such as sweet peas are raised under cloches, or any other early crop which has to remain *in situ* for most of the remainder of the year, it will not be practicable for the cloches to return to that position to protect the third crop of the season. In such cases it is obvious that a third strip must be provided if the cloches are to be used to protect the third crop. Some growers believe that there is an advantage in having a third strip available, even when such provision is not absolutely essential. It is argued that this avoids hurried preparation of the land on strip number one in between the first and third crops and that correct timing is, therefore, more easily secured. Moreover, when strip number one is eventually freed of its crop it can be used to produce an open-air crop, taking care to choose one that will benefit by the use of irrigation, which is almost certain to be part of the cloche-garden equipment.

The past two seasons, 1948 and 1949, have not been particularly favourable for some of the third cloche crops of the year. Thus in 1948 melons produced poor yields in many districts, owing to the lack of sunlight, whereas during 1949 the many large, fine melons produced by an almost record year of sunshine had to meet severe competition from abroad. Possibly next season a balance will be struck between the two. It is never wise to condemn any market-garden crop because of its failure for one cause or another during a single year or two. It may be, however, that some growers will consider stacking the cloches after the second crop of the season and using the remaining land for outdoor cropping, since production costs are bound to be a little higher while glass is being used.

The principal kinds of flowers grown with the aid of cloches are autumn-sown annuals (especially sweet peas and calendula), spring bulbs and corms, and perennial flowers for cutting. A few growers use cloches instead

of frames for accommodating boxes of bedding plants. Intensive vegetable growers can put them to valuable use for raising seedling lettuces, cauliflowers, cabbages and other plants for planting in the open early in the year. Where the outside land is available the use of cloches for raising vegetable plants may prove more profitable than for growing crops such as lettuce to maturity.

Good Marketing A brief word on marketing is necessary, since however well a crop is produced, the importance of its final presentation to the public cannot be over-emphasized. Much of the produce grown with the aid of cloches is similar to that imported from the Netherlands and other foreign countries, and consequently the home produce has to compete with very well packed and graded fruit, vegetables and salads. Generally speaking, the cloche grower, since he operates a comparatively modern section of the industry, is already fully alive to the necessity of careful and honest grading and attractive packaging. When supplies of containers and packing material become more readily available, no doubt the intensive grower will improve his packing technique still further. Every effort should be made not merely to send only properly washed and correctly graded produce to market but also to ensure that the consumer receives it in as fresh a condition as possible. It is in respect of freshness that the British grower may have an advantage over imported produce, and this advantage should be exploited to the full.

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1. Two-strip rotation. Shows the system of moving cloches from one crop to another. Note that the workers are operating in pairs.

2. Three-strip rotation. On extreme right are calendulas and sweet peas. These were protected by cloches from October to April. The cloches were then moved inwards to protect tomatoes, where they remained until the latter part of May. The glass was then moved to the position shown in the photograph to protect melon or cucumber plants. The same sequence was followed by the second two rows of cloches moving from the left towards the right. In between the two double rows of cloches the wide central pathway is shown cropped with an open air crop of radishes. When these are cleared the vacant pathway is wide enough to accommodate all 4 rows of cloches stacked up-ended and still permit workers to walk along either side of them to attend to the melon plants.

3. Pricked-out lettuce seedlings over-wintering under cloches. These seedlings will be available for planting under cold glass or in the open in early spring.

1. Typical marginal land before improvement—heather, gorse and coarse grass (West Throphill, Morpeth).

Photos. *M. Cohen*

2. Typical marginal land before improvement—coarse grass rushes, etc. (West Throphill, Morpeth).

3. Marginal land—foreground after improvement : background in original condition (Eglingham Hill, Alnwick).

Photos. *M. Cohen*

4. Marginal land—foreground after improvement : background in original condition (Eglingham Hill, Alnwick).

Photo, L. S. Clarke

Ears of *Northern Cross* sweet corn picked at the edible stage.

MARGINAL LAND

1. NORTHERN ENGLAND

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In the marginal land of England and Wales there is a great potential for the expansion of home food production. The following article is the first of a series of four, covering representative poor land in the North, Pennine, and South-West areas of England, and Wales.

THE precise definition of the term "marginal land" is by no means simple, but it may be taken as land whose productivity is relatively low by reason of inherent deficiencies in fertility, or lack of drainage, or inaccessibility, or climatic factors such as low temperatures, high rainfall, shortness of growing season, etc., or combinations of any or all of these or other limiting factors. The restoration and maintenance of productivity of such land requires expenditure substantially higher than that normally needed for good average land, and this reduces the margin of profitability. In considering the question it is important to distinguish between marginal land and marginal farming, which arises from factors other than marginality of the land itself, such as lack of capital, labour, equipment, or of farming skill.

Marginal land areas such as extensive belts of poor sand, or heavy clay, or peat, exist in many parts of the country, but in the North of England marginal land is understood generally to mean the areas which lie between hill land, on the one hand, and good quality lower-lying land on the other. It is difficult to estimate accurately the amount of marginal land in the Northern Province, but having regard to the relatively high proportion of hill and uplands in Northumberland, Durham, Cumberland and Westmorland, it is obvious that the proportion is high, and the total which is capable of improvement without unduly high expenditure probably exceeds 275,000 acres. Marginal land is widespread throughout the hilly regions, but the largest areas in Northumberland exist in parts of Glendale and the Alnwick, Morpeth, Rothbury, Bellingham, Castleward and Hexham districts; in County Durham, in the districts Chester-le-Street and Lanchester, Weardale Crook and Willington, and Darlington and Barnard Castle; in Cumberland, mainly in the Brampton and Penrith districts; and in Westmorland, the fringes of the Eden Valley, Lowther Valley, Ullswater region in the north, and the Lune Valley, the Kent Valley and the Lyth Valley in the south.

Farming in these so-called marginal areas has been traditionally concerned with livestock. In the past, rearing of store cattle and sheep has been the main feature, and although this is still true, milk production, with its financial attractions, has been steadily increasing as a result of the development of road transport; indeed on many of these farms it is now an important, if not the chief, source of income. Where milk is produced the output varies from small quantities surplus to the needs of calf rearing to output on a considerable scale. The dominant and common characteristic of marginal land is its low level of fertility, and production, whether in terms of cattle, sheep or milk, is low. The basic problem, therefore, is how best to raise and maintain fertility, and this involves some consideration of the types and characteristics of the soils occurring in the marginal land areas.

Types of Soil in Marginal Areas Broadly, there are three main types:

1. Heavy Boulder Clay. This occurs extensively and is well exemplified in Northumberland and north-east Cumberland; it is also found over much

of Westmorland, and, to a less extent, in West Durham and East Cumberland. The main feature of these soils is the extreme deficiency of phosphate, which is accentuated by the fact that much of it has lain in grass for many generations. To maintain a good sward regular dressings of basic slag, or other phosphatic fertilizers, must be applied, because of the very rapid rate of reversion (i.e., change to less available forms) which takes place. This is borne out by the results at Cockle Park, where even now after fifty years of phosphatic manuring there are signs of phosphate reversion at the end of the six-year intervals between applications.

Because of their bad soil structure, these soils are often difficult to work in the preparation of seedbeds, but where wild white clover has been established the surface soil is gradually converted into a workable loamy condition. Drainage is a problem on these soils, and pipe drains seem to have only a limited lateral effect.

All of these boulder clays are deficient in lime to a greater or less extent, depending mainly on altitude and rainfall. The most acid areas occur in Westmorland and West Northumberland, but, taken as a whole, these heavy boulder clays are not so deficient as the marginal land, on the lighter soils in the same areas. Lime alone, however, has little effect on texture and drainage and, whilst phosphate is of first importance as a factor in renewing fertility, liming is necessary to get the best response from phosphate.

2. Glacial Sands and Gravels. These are often in a hump-backed series of hills, formed as terminal moraines, or lake deposits during the retreat of the glaciers. They occur in north-west Northumberland, north-west Durham, and in the Brampton district in Cumberland. There are extensive areas of very poor grassland on these soils between Gilsland and Brampton, and south of Brampton. In their natural state these soils are very poor, and less responsive under grass than the boulder clays.

The key to the improvement of these glacial sands and gravels is lime, and in order to maintain them in a fertile condition liming at frequent intervals is necessary, on account of their porous open texture. They are also naturally deficient in humus, phosphate, potash and nitrogen. For the maintenance of a satisfactory sward, regular manurial treatment and liming must be given. Where treatment on these lines has been applied, e.g., near Wooler, and Durham City, the land has been made very productive. Horton Moor (north-east of Wooler) is an example of an area of glacial sands which awaits improvement.

3. Sandstones. There are at least three geological rock types which can be classified together as producing poor light acid soils on which there is marginal land in all four counties.

Northumberland. In this county Fell Sandstones, Cement Stones and the Scremerston Coal Group give rise to these sandstone soils. Good examples are seen due east of Wooler (Westwood Moor) and on the high rugged ridge running north and south to the west of Belford, and also round Chillingham; others occur north and south of Rothbury, in the North Tyne Valley, and south of Slaley.

Durham. Good examples of these soils occur on the Coal Measure sandstones and Millstone Grit outcropping in the Muggleswick and Tow Law districts, and also north and south of Wolsingham.

Cumberland. The most important examples are found on the unglaciated parts of the Bewcastle area, and in the Lake District.

Westmorland. Here they are found on the Silurian shales and sandstones in the Kirkby Lonsdale neighbourhood.

Whatever their geological origin, all these soils are very deficient in lime and phosphates, and they are in many respects comparable with the glacial sands. Most of the pure heather-covered areas are soils derived from the Fellstones or Millstone Grit, and are extremely acid; they are even more acid than the glacial sands on which heather is the exception, e.g., at Doddington in Northumberland, and King Harry's Common in East Cumberland.

The sandstone soils in Westmorland around Kirkby Lonsdale, and derived from the Silurian shales, are very acid, but quickly responsive to treatment. All forms of lime are effective, but it is interesting to notice that magnesian limestone has given better results than ordinary lime.

In general, the most heavily covered bracken areas occur on these sandstones.

Whilst there are marked physical differences between all these soil types, it is obvious that lime and phosphate deficiencies are common to all, and that potash shortage exists in the lighter soils, particularly the glacial sands. Any attempt at improvement must take these into account.

Methods of Improvement The direction or directions in which improvement is tackled depends upon farming policy in relation to any particular farm. There are several ways in which this may be done—by improvement of existing grassland, by suitable surface cultivations, liming and application of basic slag or other phosphatic fertilizers, by ploughing up poor grassland, liming, fertilizing and reseeding it direct, or by ploughing, liming, fertilizing, and seeding down after putting through an arable rotation, or after one or more pioneer crops. All these methods have their place, and have been tried out successfully in various parts of this Province, as in other parts of the country.

The potentialities of marginal land, and what can be achieved as a result of improvement, are perhaps best illustrated from actual experiences, of which the following are examples:

CONSHIELD, WARY-ON-TYNE (Messrs. Moralee and Ridley)

This is an interesting example of the improvement of an area of poor, unproductive pasture, situated at about 650 feet above sea level on boulder clay, and estimated to have a rental value of 4s.-5s. per acre in 1939. In that year it was decided to embark on a programme for improving 149 acres, and, as a first step 28 acres were fenced off and ploughed in June; ploughing proved to be difficult because of large stones which had to be removed. During very thorough seedbed preparations lime was applied at the rate of about 30 cwt. per acre, followed by the application of 5 cwt. basic slag and 4 cwt. compound fertilizer (containing nitrogen, phosphate and potash). The seeds mixture, which was essentially perennial ryegrass, cocksfoot and wild white clover with Italian ryegrass and 3 lb. rape and 1 lb. mustard, was sown at the end of July. Grazing started seven weeks after seeding, and 398 cross lambs were fed off the rape, the profit on these more than paying for the whole cost of the work.

In the following spring the field was stocked with 20 cattle, which subsequently was raised to 35 and ultimately to 80. These were grazed for 5 weeks, and then reduced to 55 for 3 weeks, and by the beginning of August to 16 cows with calves, and 60 Cheviot ewes. Ewes and lambs had been put on in the spring, but were removed early when it was found that they "tracked" too much.

The success of the 1939 work led to similar operations on an adjoining 34 acres in 1940. Treatment was on similar lines, but mustard omitted from the seeding. The remainder of the 149 acres has been improved by

stages, some by direct reseeding, and some after three or even four crops of sheep keep.

Some measure of the improved fertility is shown by examining the figures of stock carried. There are no figures for the individual fields in 1939, but the whole of the 149 acres before improvement was stocked with 17 Shorthorn cows with their Angus-cross calves, and 100 Cheviot ewes and their lambs. The two fields first improved—28 acres in 1939 and 34 acres in 1940—and totalling 62 acres, now carry 60 bullocks regularly each year, and these are fully three-quarters fat at the end of the season. The swards on these fields—now 9 and 10 years old respectively—consist of perennial ryegrass, cocksfoot and wild white clover, with small traces of bent here and there.

A question which is frequently asked in connection with work of this kind is: how long will the improvement last? The answer depends on a number of factors, not least manurial treatment and grazing management. These particular fields have received regular dressings of basic slag every two to four years, and very careful and skilled consideration has been given to their grazing. Except for the first year, they have not been grazed by sheep, and each year cattle are not put on until about the end of April. It is not possible to forecast how many more years the quality of the swards and the output of stock can be maintained at their present level, but after ten years the fields are still in a very satisfactory condition.

Mention should be made that adequate water was provided, and that the farmers concerned were able to put in adequate stock to eat off the flush of grass—a point of the greatest importance in the first year of reseeding.

COBRA CASTLE, EGREMONT, CUMBERLAND (Mr. T. Cook)

This farm, adjoining the open fell, lies at an altitude of about 630 feet, and has most of the disadvantages of a marginal farm. Its improvement since 1939 provides a striking example of what can be done by an enterprising farmer.

Except for about 20 acres of gravelly land, the soil consists mainly of heavy clay. The total area of the farm is 151 acres. In 1939, 101 acres were rough grazing—covered largely by gorse, blackberry bushes and rushes, and 50 acres of grass and arable in a poor and impoverished condition. At that time the stock consisted of 8 cows in milk or in-calf, 12 stirks, 9 calves and 70 ewes and their lambs. In 1949—that is, ten years later—the farm comprises 120 acres of grass and arable in a good state of fertility, and 31 acres of rough grazing, which it is hoped to convert into useful land in the near future. The stock at the 1949 June census was made up of 15 cows and heifers in milk, 2 in-calf cows, 6 in-calf heifers, 16 stirks and 1 bull, and 138 ewes and their lambs. Whereas in 1939 it was necessary to buy hay and roots to supplement the foods grown on the farm, there is now a surplus after meeting the needs of the increased numbers of livestock.

What has happened during the past ten years to bring about this remarkable change? The answer lies in the improvement of the land. Drainage was a first consideration—part being completely re-drained, and the remainder having the old drains lifted, rodded and re-laid. Dykes, fences, and gates also received attention. The whole of the farm, except the 31 remaining acres of rough grazing, has been limed at the rate of 2 tons of quicklime per acre, and treated with the equivalent of 15 cwt. per acre of basic slag. All the worst land has been reseeded direct. A start was made in 1943 under the Marginal Assistance Scheme, and by 1948, 37 acres had been dealt with in this way. The remainder, which is

capable of being cropped, has been improved under arable conditions. In 1940 the tillage acreage was 17, made up of 11½ acres oats, 3 acres potatoes, and 2½ acres green crops; the corresponding figures in 1949 were 13 acres oats, 3 acres potatoes, and 6 acres swedes and kale, a total of 22 acres. Although the tillage area has not been increased to any great extent, it is estimated that production from the 22 acres is several times as great in 1949 as that from the 17 in 1940. It is of interest to note that seed potato production is included in the farming activities.

Before the war the only source of income was the sale of cross-bred lambs and a few store cattle. Butter was made on the farm, and there was an occasional in-calf cow to sell. A change to milk production was made in 1942 (a 22-cow byre had been built by the landlord) and the average output now is between 600 and 700 gallons per month.

On the sheep side, the policy throughout has been to cross Herdwick ewes with an English Leicester ram. The size of the lambs has increased considerably, and whereas formerly they were marketed in poor store condition, they can now be sold fat or as stores, as desired, and in much improved quality.

The improvements made on this farm provide a very good illustration of the benefits that accrue from the application of knowledge and experience.

ELRINGTON HALL, HAYDON BRIDGE (Mr. G. S. Clarkson)

This is an example of a high-lying marginal farm whose fertility and production have been raised principally by the application of lime and basic slag to the existing herbage. The house and farm buildings stand 600 feet above sea level, with the land running up to 1,000 feet and bordering the open heather fells. The total acreage is 525, of which 300 acres lie above the 700 feet contour.

Since 1921 a policy of land improvement has been followed, involving the regular use of lime and basic slag by treating approximately one-third of the farm each year. This has been done on the high-lying grazings, and has effected a remarkable improvement in the composition and quality of the herbage, changing it from fescue-agrostis, nardus and rushes to agrostis-white clover mainly, with traces of perennial ryegrass, Yorkshire fog and fine-leaved fescues. All trace of heather has disappeared, though the area is surrounded by heather land. The average initial applications were 2 tons per acre of quicklime and about 15 cwt. of basic slag, and these have been repeated at reduced rates every three or four years. Similar treatment was given to the lower-lying land in the earlier years. More recently, the practice has been to give a small dressing of fertilizer each year for this land, and to lime every three or four years.

The high-lying land has been stocked with Highland × Shorthorn cows, mated with the Aberdeen-Angus bull. The cows remain out all the year round. Additional food is provided for them in the winter period, normally oat straw once per day, starting about mid-December, but in severe weather they receive additional supplies in the form of oat sheaves. Hay replaces the oat straw during February, and as calving approaches, two mangolds per cow is given as an extra. Originally this higher land carried a Blackface stock, but following the improvement was replaced by Mule ewes (Blackface × Border Leicester) many years ago. These ewes crossed with a Half-Suffolk or Hampshire Down ram produce very good lambs, the average crop being 170 per cent. The rate of stocking is one ewe to two acres. Mineralized salt licks are supplied for both the cattle and sheep.

The lower fields (i.e., below the 700 feet contour) provide grazing, hay (40–45 acres) and arable crops (20 acres oats and 15 acres of green crops, including two acres of mangolds). Part of the green crop consists of rape

and turnips sown in June for autumn grazing by sheep and lambs. Of the lower grazing, about one-half is in new leys, and it is stocked with 1½-to 2-year-old bullocks, and a flock of pure Border-Leicester sheep.

Silage is made from aftermath, pasturage, or oats cut green, and chopped for the purpose.

Some idea of the improvement effected on this farm since 1921 is obtained by comparing the stock figures then and now. In 1921 the farm carried 49 cattle of all ages, and about 390 head of sheep and lambs: the corresponding figures in June, 1949, were 232 cattle of all ages and 474 sheep of all ages.

It is interesting to note that Mr. Clarkson feels that supplementary mineral feeding for both cattle and sheep is worth while from the point of view of general health and well-being. A considerable volume of evidence is accumulating that major and trace mineral deficiencies in sheep and cattle are widespread—much more so than is generally recognized, and investigations on this point by the N.A.A.S. and the Veterinary Advisory Service are in progress in the Province.

These examples of what has been done by enterprising and progressive farmers are evidence that marginal land tackled in a pioneering spirit is capable of substantially greater production. In these brief accounts no reference has been made to costs, but in each case the farmer concerned is satisfied that the expenditure incurred has well justified itself. With the knowledge available, and given a widespread attack on marginal land, a significant and positive contribution can be made in livestock expansion. Assistance under the Ministry's Marginal Production Scheme provides a valuable incentive to this end. The large area formerly under cultivation a century or so ago, as judged by the old rigs and furrows, seems to be the most promising on which to operate, and its improvement in fertility and production would push the marginal boundary further up the hills.

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SCIENCE IN THE MUSHROOM INDUSTRY

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SEVERAL strains of mushrooms similar to the common field mushroom have been cultivated on a commercial scale for over two hundred years, and scientists have taken an interest in some of the problems of the industry during much of that period. Mushroom-growing is still mainly a traditional craft: although scientific investigation has supplied a background of precise knowledge and introduced some improvements, the basic operations remain the same as they were a century ago. Horse manure is still the usual medium, and the process of composting it is essentially the same.

The first practical application of scientific methods was the development of spawn from germinated spores about 1895. The wild spawn previously used was derived from growing mycelium, and was subject to variation in quality and to contamination with parasitic and competitive fungi and with insects. Pure culture spawn was first grown about 1905 on

a sterile medium inoculated with pure cultures derived from single spores or aseptically from mushroom tissue. All the operations involved in spawn-making could be carried out with full aseptic precautions, and it became possible to maintain pure cultures for trial, selecting for use those which were most reliable and productive.

The production of pure culture spawn, using composted horse manure, has been described by W. M. Ware and H. H. Glassscock (1947), and that of grain spawn by C. Terrier (1946). Grain spawn, using wheat or rye, is widely used in the U.S.A. and is particularly suitable for highly mechanized units where spawn is scattered mechanically on trays of prepared compost. It must be used fresh, and it encourages rats and mice which dig it out of the beds. Tobacco spawn is also used in the U.S.A. The wide, hollow tobacco stems hold water and at the same time allow passage of enough air for vigorous mycelial growth. The trace of residual nicotine repels insects, and tobacco spawn does not deteriorate rapidly in storage.

Mushroom Nutrition Styer (1928, 1930) showed by pure culture experiments that mushroom mycelium can use as sources of carbon glucose, maltose, xylose, cellulose, xylan, casein, albumin, pectin, and a wide range of plant residues. Growth was most vigorous on materials containing lignin. He found that ammonium salts, urea, glycine, asparagine, peptone, and proteins were adequate sources of nitrogen. Similar results have been obtained by others, and there is no difficulty in growing mushroom mycelium in pure culture on the usual sterile media. Unfortunately the mushroom does not fruit on such media; indeed, fructification has been obtained only on materials containing humus, usually fermented fibrous vegetable matter. This excludes anything resembling the simplicity of pure culture methods in nutritional work on the mushroom as a crop, and less direct methods have been employed.

There is analytical evidence (e.g., Hebert and Heim (1911), Waksman and Mc Grath (1931), Waksman and Nissen (1932) to show that the mushroom takes up considerable amounts of cellulose, hemicellulose, lignin and protein from horse manure composts. The use of this analytical approach is restricted to major nutrients, owing to the presence in spent compost of much mushroom mycelium, which is necessarily included in the final analysis; for example, the mushroom must have taken up from the compost some of the protein which is recorded as still forming part of the spent compost. In fact, this type of analytical balance has only been used qualitatively to demonstrate that cellulose and lignin are major sources of carbon, and that protein is the main source of nitrogen. It has not been applied to phosphorus, potash or any of the minor nutrients.

The most recent report on mushroom nutrition, and one of the most comprehensive on the mycelial phase, is that of Treschow (1944). He confirmed that pentoses, hexoses, disaccharides, some organic acids, and pectin were good sources of carbon. Starch, inulin, tartrate, and malate were less satisfactory. He found that ammonium salts and several amino-acids were equally good as sources of nitrogen, but nitrate was inferior.

In the first detailed quantitative study of mineral requirements, Treschow found that a balance must be maintained between calcium, magnesium, and potassium. The best growth was obtained when all three were between 0.0025M and 0.0075M (in a liquid medium). He found that calcium was particularly necessary, and suggested that the function of gypsum in Pizer's (1937) experiments might have been to adjust the calcium potassium-magnesium balance. The occurrence of calcium oxalate crystals on mushroom mycelium is well known, and a considerable amount of

calcium must be deposited in this form. It is not known whether this is a necessary detoxication or merely incidental, due to the excretion of oxalate in presence of dissolved calcium. Phosphorus was also found necessary by both Styer (1928) and Treschow.

Stoller (1941) recommended the use of a mixture providing eight trace elements, based on the analysis of mushroom ash, in synthetic composts. Treschow found iron necessary for mycelial growth, but the addition of copper, manganese, and zinc had no effect.

To summarize, studies of mycelial growth have shown that the mushroom can use a wide range of sources of carbon and nitrogen and also needs calcium, magnesium, phosphate, potassium and iron. Analysis of horse manure composts has shown that in practice the chief sources of carbon and nitrogen are cellulose, lignin and protein. The presence of sodium, aluminium, sulphur, silicon, chlorine, manganese, chromium, zinc, boron, bromine, and iodine in mushrooms is presumptive evidence but not proof that they are needed.

Synthetic Composts The prospective decline in the use of horses and in the supply of horse manure stimulated a search for possible alternatives, and work on this subject has been in progress, mainly in the U.S.A. and France, for twenty years. Existing knowledge suggested that a suitable compost might be made from straw by replacing the nitrogenous and mineral constituents of horse droppings. Demolon (1935), Sinden (1938) and Lambert (1941) described composts developed on these lines. Urea was popular as a source of nitrogen because it left no inorganic residue. Demolon also added a small quantity of nitrate. Sinden added wheat grain as a source of readily available carbohydrate to promote fermentation and heating in the stack. Lambert added dried blood with the urea, and soil to prevent leaching and loss of nitrogen.

Single arbitrary formulae of this type were criticized by Stoller (1941, 1943), who laid down proportions of nitrogen, phosphorus and potassium which he claimed could be added in any form to lignin-containing material to form a satisfactory mushroom compost. He also recommended the use of a mixture of mineral salts to supply the trace elements, familiar to workers on plant nutrition. It is unfortunate that more details are not given of the "extensive experimentation" referred to in Stoller's (1943) paper which led to his ratio 13 lb. N, 4 lb. P_2O_5, and 10 lb. K_2O per ton of the fibrous material containing 70 per cent moisture. Nor do the widely scattered yields with different sources of nitrogen inspire confidence in the proposition that this ratio is the only, or even the most important, characteristic of a satisfactory compost.

Stoller (1941) also described an entirely new approach to mushroom cultivation in the use of a process which he called "coprination". The published descriptions (Stoller, 1941, 1943) leave the details of this process a little obscure, but it seems to depend on a reaction rather similar to the tanning of leather, nitrogeneous substances combining with a coprinating agent such as the lignin in spent liquorice root, to form products which are available to the mushroom but not to most of those other micro-organisms which, if they could flourish, would outgrow the mushroom and eliminate it from the bed. One of the objects of composting horse manure is said to be to convert the carbon and nitrogen present into forms which are readily available to the mushroom and much less so to any commonly occurring mould which might compete with it. There have been occasional references to Stoller's coprinating process in trade periodicals but there is no indication of its extensive use by commercial growers.

Stoller's formula has formed the basis for a number of experiments on orthodox lines by individual growers in Great Britain. The general opinion seems to be that these synthetic composts give an excellent spawn growth and one or two good flushes of mushrooms, but they lack stamina and the crop fades out at a lower total yield than that usually obtained with horse manure. Assessment of these very scattered observations is made more difficult by the wide range of yields "normally" obtained; so much so that a critical-minded statistician who saw the yield figures on most commercial farms would dismiss as insignificant any single difference less than 50 per cent below or 100 per cent above the annual average yield.

Sinden (1946) describes in detail the preparation of a synthetic compost which gave yields equal to those obtained with horse manure. The nitrogen content is not directly comparable with that recommended by Stoller, but Sinden and Stoller both found the potassium requirement to be 30 lb. K_2O per ton of dry matter. Sinden's compost was based on a mixture of wheat straw and maize fodder. Practically all American synthetic composts contain other organic materials, such as wheat and brewers' grains, and they cannot be used in Great Britain in their original form. According to Sinden (1949), synthetic composts are not popular in the U.S.A., where growers and research workers have recently concentrated more on methods of economizing in horse manure than on replacing it. They are developing rapid methods of composting to reduce losses, and using shallow beds which give better yields per ton of manure.

There are several proprietary mixtures on the British market, most of them intended for use with straw, and their claims range from a conservative "1 lb. per sq. foot can be obtained" to the quotation of individual cases where crops of 3 lb. per sq. foot have been grown. To put these claims in their proper perspective they must be compared with the equally wide range of yields from crops grown on horse manure; authentic yields of 4 lb. per sq. foot have been obtained, and 3 lb. is regarded as a good average crop on some farms, while others average no more than 1 lb. per sq. foot. The comparison of yield data is complicated by the fact that a mushroom crop has no sharply defined end. Some growers operate on a fairly tight schedule, emptying their houses after picking for three months or less; they find that the diminishing rate of production makes further picking uneconomic, although their composts would often produce another ½ lb. per sq. foot or even more if they were kept going to the point of exhaustion. Other growers pick for periods up to six months, emptying their houses only when production has completely ceased. These wide variations emphasize the need for properly designed experiments to assess the value of any artificial compost.

A systematic investigation of the mushroom's NPK requirement in wheat straw composts has led to a formula (Edwards, 1949) which is believed to give yields comparable with those obtained from heavy stable manure. Only materials available in Great Britain are used.

Diseases and Competitors Conditions in a mushroom house are naturally ideal for the growth of many other fungi, and the mushroom forms a ready host for several of them. Mycologists have identified three common parasitic fungus diseases. *Verticillium malthousei* (Ware, 1933) and *V. psalliotae* (Treschow, 1941) cause disease characterized by brown marks on the cap, turning grey. If attacked when small, the stalk may split and peel, and the whole mushroom may be deformed. *Mycogone perniciosa* causes soft rotting, with severe deformity of the mushroom. *Dactylium dendroides* (cobweb

disease) grows over the mushroom, as the very descriptive popular name suggests. The occurrence, prevention, and treatment of these diseases are described in most books on mushroom-growing, and they have been summarized by Atkins (1945, 1948). *Cephalosporium lamellicola* sometimes attacks mushrooms, causing "gill mildew" or "flock", but this is comparatively rare.

There are also diseases attributed to the presence of specific bacteria, but the relation between organism and disease is less clearly defined. Bacterial disease appears when humidity is excessive and is usually controlled by improving air conditions.

The distinction between fungi parasitic on the mushroom mycelium (e.g., *Myceliophthora lutea*, Mann, 1947) and non-parasitic competitors in the bed (e.g., white and brown plaster moulds) may be real and important, but it is extremely difficult to apply in some cases.

Several mushroom bed invaders are well known and methods of prevention have been found. "Pasteurization" at 140° F. in the beds kills the spores of *Scopulariopsis fimicola* (white plaster mould) and *Papulaspora byssina* (brown plaster mould) and also those of the parasitic fungi already mentioned.

The responsibility of *Fusarium* sp. for a "damping off" disease of mushrooms, described by Wood (1937, 1939), was questioned by Kligman and Penney (1943) who failed to repeat Wood's experiments. No one appears to have studied this disease more recently.

More information is also needed about *Myceliophthora lutea* (*Vert de Gris* of Costantin and Matruchot (1894), Matt disease of Manns (1947)), and *M. sulphurea* which, according to Sinden (1948), does similar damage in mushroom beds, but forms small colonies instead of a widespread mat of mycelium.

The growth of *Cephalosporium costantinii*, *Geotrichum* sp., and *Trichoderma viride* on mushroom beds is said to injure the crop. Insufficient is known about these fungi to say with certainty under what conditions they cause damage or how they can be controlled.

Pseudobalsamia microspora (truffle) is much better known and is dangerous because of the resistant nature of its spores. They have been shown by Lambert (1932) to survive five hours at 180° F. and to withstand treatment with formalin and phenolic fungicides at the usual strengths. Stoller (1943) found that ammonia evolved at a high temperature in nitrogen-rich composts killed truffle spores, but this observation has not been repeated. Sinden (1948) suggested that truffle becomes established on the composting ground, even on concrete, and thence invades the compost. It may be partly controlled by spraying the ground with strong formalin, to prevent growth of the mycelium, before making or turning a stack. He did not consider that carry-over in the growing-house was a serious cause of infection.

The symptoms of a "Mummy disease" were described by Tucker and Routien (1942). They found that it spread very rapidly over mushroom beds, but they failed to isolate any causal organism and suggested that it might be due to a virus. Various "weed" fungi have been reported, e.g., *Peziza vesiculosa*, *Clitopilus cretatus*, *Clitocybe dealbata*, *Coprinus* sp., *Panaeolus* sp., but they do not appear to cause widespread damage. Many growers regard the presence of ink-caps (*Coprinus*) as promising a good crop of mushrooms.

Taking a general view of mushroom diseases, the most urgent call is for further study of bacterial disease and of those fungi which invade the compost and soil. The grower can improve his position by attention to farm hygiene and making full use of existing knowledge.

Pests The mushroom house is a highly favourable breeding place for insects and allied pests, which multiply rapidly if preventive measures are not taken.

Austin and Jary (1933, 1934) have described the species commonly found and the damage they cause It is generally agreed that Sciarid and Phorid fly larvae are economically the most serious pests, and if unchecked they can do enormous harm by eating the mycelium and burrowing into the mushroom stalks and caps. Cecid larvae were also found to burrow into mushrooms, particularly on the stalk. They commonly multiply paedogenetically, and may pass unnoticed by growers in the absence of the adult fly.

Many different kinds of mites are found in mushroom beds, and some of them undoubtedly cause damage. The mites identified as causing most damage in mushroom beds are *Tyroglyphus mycophagus*, *T. dimidiatus* (*longior*), and *Linopodes antennaepes*. Other *Tyroglyphus* sp., *Caloglyphus* sp., and *Eberhardia* sp. have also been found. In America *Tarsonemus* sp., *Pigmaeophorus americanus*, and *Histiostoma gracilipes* sometimes cause damage. It seems unlikely that insecticides used on mushroom beds will have any selective action between these and the predatory gamasid mites or the harmless *Histiostoma rostroserratum*. From the grower's point of view the only good mite is a dead one ; even when they do no direct harm, they help to spread disease spores. Springtails are sometimes found in large numbers, and they can do considerable damage, but apart from the identification of a few species little attention has been paid to them. Peak heating to at least 120° F., combined with fumigation, eliminates all these pests and gives the mushroom bed a clean start.

A recent investigation by Lambert, Steiner, and Drechsler (1949) has shown that eelworms (*Ditylenchus* sp.) are responsible for damage in the form of a soggy compost, formerly known in the U.S.A. as Cephalothecium disease. The fungus associated with this condition has now been identified as *Arthrobotrys superba*, which is predaceous on the eelworm. *Arthrobotrys* sp. has also been observed in association with eelworms in mushroom compost in Great Britain (La Touche, 1948), but no relation to damage in the bed was established.

Flies can be controlled later with the old-established pyrethrum and nicotine insecticides, but no reliable method of treating a serious infestation of mites or springtails has been found. Great hopes are entertained that some of the new insecticides will solve these problems. DDT and benzene hexachloride certainly kill phorid and sciarid flies and many growers use them regularly.

Their effect on Cecid larvae, mites and springtails is more doubtful, but there may still be scope for improvement in the form of dispersion and technique of application. These pests may prove to be susceptible if contact with the insecticide can be made more effective. The development of DDT and benzene hexachloride for some purposes was so rapid under the strain of war-time needs that we are apt to expect too much when considering their application to other specialized fields.

The older insecticides will not disappear entirely; the rapid knock-down action of pyrethrum retains its special value and has not been equalled by the new insecticides. Combinations of old and new insecticides may be expected to make the best use of their individual properties, and intermittent use of several of them may be necessary to overcome acquired resistance to one in continuous use.

Benzene hexachloride has the special advantage of combining some fumigant action with its contact and stomach toxicity. Some doubts

have been expressed about the effect of DDT on mushrooms and on the mycelium, and some growers have abandoned its use on account of the spotting which they observed on the caps after using DDT dusts.

An inquiry and a small-scale experiment conducted by the Mushroom Growers' Association (Atkins, Edwards and Sparkes, 1949) produced no conclusive evidence of injury by DDT. Recent work by Bels in Holland and Weigel in America suggests that DDT can be used effectively in small doses without injury, but when applied at 1 lb. per 1,000 sq. ft. as a surface treatment (Weigel, 1949) or mixed in the compost, 1½ lb. DDT per ton (Bels, 1948), it does reduce the yield. Unsuitable formulations may be injurious at lower concentrations. American workers particularly are also concerned about the possibility that toxic amounts of DDT may be absorbed by the mushroom.

Doubts about tainting by benzene hexachloride have been dispelled by its continuous use on a number of British farms for several years without any complaints from consumers.

There are other new insecticides, such as azobenzene, parathion, hexaethyl tetraphosphate and tetraethyl pyrophosphate and the systemic insecticides, which may fill any gaps left by DDT and benzene hexachloride. Their effect on the mushroom is less certain, but HETP has been used a few times to control tyroglyphid mites without any apparent ill-effects on the mushroom crop. It is reasonable to expect that in a few years the mushroom grower will have a quick and effective antidote for any pest which may trouble his crop. The elimination of flies and mites will also tend to reduce the spread of disease.

Progress in Cultivation Several advances in general cultural methods have been initiated as a direct result of scientific study. The addition to composts of gypsum (up to 28 lb. per ton), adopted as routine by many mushroom growers, was suggested by Pizer (1938) as a result of his study of composts in which the mushroom would not grow. He found that calcium ions flocculated the colloidal material which was making the composts "greasy", and he suggested that gypsum was particularly suitable to prevent greasiness because of its favourable solubility, high enough to be effective without any risk of local excessive concentration. All composts do not need gypsum, but it is an excellent form of insurance against the risk of greasiness.

Another development arose from the combination of traditional methods and Lambert's (1941, 1942) study of the conditions in fermenting mushroom composts. It has long been the practice of some growers to "peak-heat" their houses immediately after filling. The compost at this stage usually ferments, and with some artificial heat the temperature can be raised to any desired extent. The usual object is to reach 120°–140° F. and to maintain it for 24–48 hours. Lambert studied the distribution of temperature and aeration in compost heaps, and their effect on the growth of mushroom mycelium in samples from different parts of the heap. He found that aerobic fermentation at 120–140° F. gave the best compost, and that this fermentation would improve compost which had been fermented anaerobically or at other temperatures. This established a sound basis and defined the conditions wanted in the traditional "peak-heat". From it Lambert went on to develop a technique of rapid fermentation which saves time and reduces losses of manure during composting. The manure is composted in a stack in the usual way for 7–14 days, and is then made up into beds in the house. Heat is applied, often by blowing in steam, to raise the temperature of the compost to 120°–140° F., which is maintained

for a period up to a week, according to the condition of the compost. Considerable skill is needed to control the fermentation and to judge when to stop it. Many American growers have adopted the rapid fermentation method, and they cool off the compost as soon as its *p*H falls below 8. The larger size of most American mushroom farms favours their national inclination towards mechanical and instrumental control, and they accept such methods more readily than do British growers. Some British growers regard prolonged fermentation in the house as a waste of cropping space and time. A few have tried it, but it has not become popular.

The introduction of the tray system must be mentioned, although it arose from the industrial outlook of American growers rather than from scientific discoveries. Using rapid fermentation and mechanized at every possible stage, it put mushroom-growing on a mass production factory basis.

A systematic investigation of casing soils is urgently needed. Bewley (1946) and Pizer and Leaver (1947) have studied this problem, but our present knowledge is quite empirical, and we are completely ignorant of the scientific principles which govern the action of casing soil. The problem is complicated by the intimate relation between watering and the nature of the soil. It has recently been reviewed by Edwards (1949).

Too little attention has been paid to the intermediate stages between the growth of mycelium and the final crop. Pizer (1937) distinguished three stages, mycelial growth, strand formation, and appearance of the mushroom, but after the mushroom is formed its rate of growth and the onset of ripening, represented by opening of the veil, both affect the final weight of the mushroom. Apart from their relation to commercial yield, a study of these stages of development individually should contribute much to our knowledge of the biology of the mushroom.

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THE MINISTRY'S PUBLICATIONS

Since the date of the list published in the September, 1949, number of *Agriculture* (p. 288), the undermentioned publications have been issued.

BULLETINS Copies are obtainable at the prices mentioned from the Sales Offices of H.M. Stationery Office or through any bookseller.

No. 69 Onions and Related Crops (*Revised*) 9d. (10d. by post)

No. 95 Strawberries (*Revised*) 2s. 0d. (2s. 2d. by post)

LEAFLETS Single copies of not more than 16 leaflets (four in any one group) may be obtained, free of charge, on application to the Ministry, 1-3 St. Andrew's Place, Regent's Park, London, N.W.1. Copies beyond this limit must be purchased from the Sales Offices of H.M. Stationery Office, net price 1d. each (2d. by post), or 9d. per doz. (11d. by post).

Advisory Leaflets

Group II. Pests and Diseases of Farm and Horticultural Crops

(b) FUNGI

No. 271 Potato and Tomato Blight (*Revised*)

No. 346 Violet Root Rot (*New*)

Group VI. Other Subjects

No. 122 Sugar Beet: Sowing to Singling (*Revised*)

No. 347 The Preparation of Beeswax (*New*)

No. 348 Sugar Beet: Singling to Delivery (*New*)

No. 349 Spring Cabbage (*New*)

No. 350 Winter Cabbage and Savoys (*New*)

No. 351 Summer and Autumn Cabbage (*New*)

Animal Health Leaflets

No. 28 Fowl Paralysis (*New*—superseding Advisory Leaflet No. 272)
No. 29 Foot-and-Mouth Disease (*New*—superseding Advisory Leaflet No. 148)
No. 31 A Substitute for Dishorning (*New*—superseding Advisory Leaflet No. 228)
No. 32 Pulpy Kidney Disease (*New*—superseding Advisory Leaflet No. 325)
No. 33 Bovine Contagious Abortion (*New*—superseding Advisory Leaflet No. 93)
No. 34 Sheep Maggot (*New*—superseding Advisory Leaflet No. 4)

Marketing Leaflets

No. 105 Recommended Grades for Tomatoes (*New*) 2d. (3d. by post)
No. 106 Recommended Grades for Lettuces (*New*) 2d. (3d. by post)

OFFICIALLY APPROVED INSECTICIDES AND FUNGICIDES

Since the date of the list published in the October, 1949, issue of *Agriculture* (p. 338) the following names of proprietary products have been added to the approved list under the Ministry's approval scheme.

Miscible Tar Oil Winter Washes:		
Swift and Sure Tar Oil Winter Wash	Mark Smith Ltd.	**D 338**
Stock Emulsion Tar Oil Winter Washes:		
Pest Control Tar Oil Standard Winter Wash	Pest Control Ltd.	**E 313**
Copper Fungicides to be used as Sprays:		
Blitox Wettable Copper Fungicide	Pest Control Ltd.	**K 328**
Stock Emulsion Petroleum Oil Winter Washes:		
Edwent 66% Petroleum Oil Winter Wash	J. M. Stokes Ltd.	**S 339**
DDT Insecticides to be used as Sprays:		
Psylortox 250	Pest Control Ltd.	**AE 330**
DNC-Petroleum Oil Winter Washes:		
Edwent 1-5 Dinitro-ortho-cresol Winter Wash	J. M. Stokes Ltd.	**AZ 340**
Pest Control DNC Petroleum 1.3% Oil Fixed Winter Wash	Pest Control Ltd.	**AZ 316**
Pest Control DNC Petroleum 2.2% Oil Fixed Winter Wash	Pest Control Ltd.	**AZ 317**
Sterilite DNC Petroleum Wash	Wm. Butler and Co. (Bristol) Ltd.	**AZ 342**
Calomel Dusts (4%):		
ITP 4% Calomel Dust	International Toxin Products Ltd.	**BB 320**
Metaldehyde Slug Baits:		
ITP Slug Killer	International Toxin Products Ltd.	**BC 304**

Products D 9, E 44, K 93 *and* L 234 *have been withdrawn from the list by the manufacturers. In the October,* 1949, *List, product* O 170 *was erroneously given under Nicotine Sprays instead of under Nicotine Dusts.*

Ministry of Agriculture and Fisheries, Plant Pathology Laboratory, Harpenden, Herts. November, 1949.

Correction

The name of the farm referred to in Mr. P. G. Swann's article "High Quality Kale Silage-making" (September issue p. 262) should read "Easton Farm" not "Eastern Farm". Also we are now advised that this property is owned by the Commissioners of Crown Lands; Messrs. J. Horton and Sons are the tenants of the farm.

Official Seed Testing Station: 1949 Report The number of seed samples received for analysis at the Official Seed Testing Station, Cambridge, during the twelve months ended July 31, 1949, was 77,964, a decrease of 4,773, as compared with the previous year. The decrease was marked in the cereals and pulses group, but there was an increase in the grasses. Comparative figures by species groups are:

Species Group	1947–48	1948–49
Clovers	10,621	8,410
Grasses	8,607	9,138
Cereals and pulses	41,174	38,425
Roots and vegetables	21,822	21,234
Control samples	513	757
Total of all samples	82,737	77,964

Comparative figures of the total number of samples tested during recent years are:

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
74,528	75,834	76,692	79,157	80,019	82,737	77,964

Many investigational tests are also necessary to solve problems connected with routine testing; during 1948–49 these numbered 1,988, as against 1,285 in 1947–48. Tests to determine moisture totalled 866, as compared with 939 in the previous year, and the number of celery samples examined for disease infection also showed a slight decline from 152 to 125.

"Head" samples received in connection with the Wild White Clover Certification Scheme numbered 30, while the type samples sown from certified pastures numbered 7. In the previous year the numbers were 30 and 26, respectively. The customary inspection of the plots sown down from "head" samples was made by the Plot Inspection Committee in July.

A Seed Testing Course was held from June 8 to July 11, 1949. Nineteen students attended, including three members of the Official Seed Testing Station staff. In the subsequent examination taken by twenty-one candidates, sixteen satisfied the examiners in both written and practical work; four passed in the practical examination but failed in the written papers; and one passed in the written papers but failed in practical work. In addition, three candidates who sat the written papers only (having passed the practical examination in a previous year) failed to reach the required standard.

Extra Cereals for Stock Feeding Increased supplies of coarse grain have been bought from non-dollar sources, and a special non-recurrent issue of extra cereal feedingstuffs will be made this winter for cattle, pigs and poultry, to offset the effects of this year's drought. It will also be possible to make some improvements in the ration scales for domestic pig and poultry-keepers, including members of pig clubs, until further notice. In view of the uncertainty of future supplies of animal feedingstuffs from non-dollar sources, however, *these changes in no way lessen the need for an increased tillage acreage and the maximum possible degree of self-sufficiency in the provision of animal feedingstuffs*. Details of the changes are as follows:

COMMERCIAL STOCK. *Fat Cattle.* To improve the condition of cattle being fattened for slaughter during the period January–June, 1950, inclusive, an allowance of 4 cwt. of cereal will be given on application (before December

15) to the County Agricultural Executive Committee. The issue will be in 1 cwt. cereal coupons per beast per month for the four months beginning December.

Dairy Cows. The "cereal deduction" of 60 lb. of cereal per cow per month will be suspended completely during the two months December, 1949, and January, 1950; this will have the effect of reducing the level of self-sufficiency in cereals to that required in protein, namely, the first half gallon per cow per day. During the period February–April, 1950, inclusive, the level of self-sufficiency in cereals which farmers are expected to attain, i.e., the first 1½ gallons of milk per cow per day, will be reduced to the first gallon. The "cereal deduction" for these last three months will thus be reduced to 48 lb.

Calves 6–12 months old being reared for Milk or Beef. From December, 1949, to April, 1950, inclusive, the monthly ration will be increased by ¼ cwt. of cereal, bringing the ration up to 1 cwt. of cereal and ¼ cwt. of protein.

Commercial Pigs and Poultry. A supplementary issue of cereal amounting to 50 per cent of the total combined protein and cereal ration already issued under the basic and extended schemes for the period September–December, 1949, is being made in cereal coupons without the need for application.

DOMESTIC PIGS AND POULTRY. Because of the increased supplies of coarse grain the following revised scales will apply from January 1, 1950, until further notice:

Pig Clubs. The monthly ration of pig food will be increased from 70 lb. to 84 lb. per pig, and rations will be allowed for a second pig if kept by club members.

Other Domestic Pigs. The monthly ration will be increased from 56 lb. to 70 lb. and will in future consist of balanced pig food as supplied to pig clubs.

Domestic Poultry. The monthly allowance of balancer meal will be increased from 4 lb. to 5 lb. for each surrendered shell egg registration.

Potash Supplies To meet the ever-increasing demand for potash, special efforts have been made to import supplies early this season. These efforts have been so successful, however, that stocks are piling up at the fertilizer works and stores, and unless more orders for immediate delivery are placed by farmers, imports will be slowed down. All growers with storage accommodation are therefore asked to take immediate delivery of their potash fertilizers.

Nature Month by Month : December There is a nip in the air this morning, and when I got up the farmhouse roof was white with frost. The grass tufts still crunch pleasantly underfoot. Our neighbours are out with guns and ferrets; rabbits should bolt well on a day like this. The good red Devon earth, ploughed and waiting, is bright in the winter sunshine. Across the field there flies a prospecting crow, like other daytime birds finding it necessary to work harder for a living on these short December days. For the wood-pigeons the lean times have come, and before long they will be at the winter greens.

The trees are stark and bare, and the cart-ruts in the lane are filled with dead, brown leaves. Yet even now, I think, I could find a dog-violet or

two under the more sheltered banks. More than once I have seen them blooming in December, and primroses too. In the crannies of the old garden wall some flat discs of pennywort still show green.

Save for those dancing gnats which came out during a mild spell I have seen no insects on the wing for some weeks past, although doubtless there have been some male winter-moths around the lighted windows at night.

Darby and Joan, our barn-owls, sleep by day in the old dove-cot where they reared their young last spring. At night they have good hunting in the farmyard, and many a mouse falls to their talons. Darby has a trick of cruising under the farmhouse eaves, now and then flushing a roosting sparrow as a change of diet; but mostly rodents are his meat.

If really bad weather should come the tough little moorland ponies will drift down to the village in numbers in search of better provender. Already some are in the lanes, busy on the grass verges. The moorland foxes, too, are likely to visit us at this season. Living is hard on the Moor in winter, and at night we must look to the fastenings of our fowl-houses.

The river is fairly quiet, now. In the sandy margin at a bend there are some footprints as evidence that an otter passed that way last night. The prints were not there yesterday, nor, if I know otters, will there be any fresh ones there tomorrow. Heron, dipper and kingfisher are busy in the upper reaches, and a really cold snap may bring in a mallard or two.

Christmas will soon be here again, and even in our village the small boys will raise their shrill uncertain voices in praise of the good king "Wencerslosh", knowing well that no matter how indifferent their performance they will pouch a copper here and there. Soon, too, the days will lengthen and Nature's great cycle start once more.

F.H.L.

BOOK REVIEWS

Pests of Farm Crops. J. H. STAPLEY. Spon Agricultural Series. 21s.

The link between science and agriculture has never been closer than at the present time, because more scientists appreciate the agricultural viewpoint and more farmers realize that agricultural progress is dependent largely upon scientific work. This link is forged largely by books which deal with the "field" aspects of the applied science concerned, and Mr. Stapley's book is a good example. It is "written primarily to interest farmers and all others who meet pests in the open field".

It commences with a survey of the more important "insect" pests of farm crops, with a key to their identity, based upon the nature of the injury they cause. Then follows a brief description of insects in relation to their food and environmental conditions, an account of the principles underlying control methods, and concise information on the chief insecticidal substances and their use. The main portion of the book deals with the chief insect pests of crops, including eelworms and other non-insect animals. Mammals and birds do not come within the scope of the book. The treatment of the subject matter is based upon entomological classification and not under crop headings, but this classification is introduced by a concise explanation, together with an account of insect structure and development.

It is not a text-book in the accepted sense, neither is it simply a book to be read. Data from field and laboratory trials are frequently quoted; there are many references to scientific work and a useful index to authors, all indicating that the subject is approached from the angle of the advisory worker. This indeed is the atmosphere of the whole book. Its objective is to show how the applied scientist arrives at his practical conclusions.

Many farmers who are prepared to spend time seriously with it will find this volume most useful for reference; agricultural students and field advisory officers should certainly not omit it from the library.

S.G.J.

Sheep Husbandry. ALLAN FRASER. Crosby Lockwood. 25s.

A picturesque and original personality, a distinguished scientist with an extensive background of practical experience and a gifted writer, Dr. Allan Fraser is always readable, often provocative and generally convincing. He distrusts the dogmatism of modern science as applied to our oldest industry. When there is a conflict of opinion between scientist and practitioner it is too often assumed that the latter is necessarily wrong. "Traditional knowledge of sheep farming has brought mutton and cheese to our table, clothes to our wardrobes regularly and unfailingly for countless generations. To have done this so successfully it must, in the main, be in accordance and keeping with the true laws of biology . . . Will science do better? That is still a question".

In regard to stock breeding, Dr. Fraser's views seem to be more or less in harmony with those of most modern geneticists. But he is frequently critical of current methods of selecting and rearing rams of hill breeds, where breeders base their selection on standards little related to utility. He stresses the point that the larger portion of the female progeny is returned for breeding on the hill and must inherit some of the properties of their sire. If they, like their sire, tend to lowland type their nutritional demands will not be too exacting for the hill climate and hill fare, which they will have to tolerate during the five or six years of their reproductive life.

By contrast, under the lowland folding system, ram breeding has been combined with the commercial production of mutton and wool within the same flock. Now, however, because of economic conditions, the folded flock seems destined to vanish except for ram breeding, and is being replaced by "grass" sheep, commonly Half-breds or Cross-breds put to a Down ram. This has the disadvantage or inconvenience that the flock has constantly to be renewed. The Scottish Half-bred ewe (Border Leicester x Cheviot), is unbeaten for this purpose, but Dr. Fraser admits that certain other breeds with hill blood in their ancestry are proving satisfactory for grassland where a self-contained flock is preferred to a "flying" one. He mentions specifically the Clun Forest and Kerry Hill.

It may be that for new pastures of high productivity the most economical self-contained grass breed has not yet been evolved. The most prolific and best mothers from the milking standpoint are probably Border Leicesters and Dorset Horns. Why not combine the two, using the Border Leicester ram to get hornless progeny?

As regards nutrition, Dr. Fraser maintains that science has still more to learn from the practical sheep feeder than vice versa. Animals vary in their powers of digestion and metabolism. Consequently, "in all systems of rigid rationing, everybody gets either too little or too much. Only the theoretical completely average individual gets just enough —but today it is fashionable to strike an average and call it science". Yes, but needs must when the devil drives. Anyway, with sheep the flock is the unit and exactitude in feeding is out of the question.

Dr. Fraser is scathing about grassland research. It has been erected into an independent subject of study concentrating on production with the result that it tends "to give greater consideration to the grass than to the stock that graze it . . . A pasture that can only be maintained in excellence by remaining ungrazed at the times of year when stock need grazing most is not excellent pasture at all . . . The real problem of all pasture as a basic food is its seasonality".

The experts' retort to this would, I suppose, be "management and efficiency" (would it also include cost?)—a special seed mixture for every season and silage to help out in winter, but before dogmatizing or particularizing on this aspect, Dr. Fraser thinks they might get aroused and sit at the sheepman's feet. "The facts are that an intelligent, observant, and experienced shepherd or flockmaster knows far more about sheep, as sheep, than any scientist, simply because he has studied the sheep as a sheep, and it really is, as an integrated unit and not as a mere collection of analysed parts. He knows . . . that breeding, feeding, and shepherding of sheep have as much to do with sheep disease as has any specific germ or virus".

Science, practice and philosophy—all go to the making of a good shepherd and a highly stimulating, enlightening and entertaining book.

J.G.S.

Wheatsheaf and Willow. NORMAN WYMER. Lutterworth Press. 15s.

Many books have been written on rural England, but in *Wheatsheaf and Willow* I think Norman Wymer has provided a book packed with an unusual amount of interest. You will be taken at great pace through the towns and countryside of the Eastern Counties and parts of the East Midlands and your interest will be kept with tales, custom and history, that you find yourself quickly realizing that you know little of England other than its roads. This book will help you to discover England.

Mr. Wymer gets behind the picture postcard scene and in a brief fascinating way, the stories of bygone years and the way of present-day life are told with a depth of sincerity which cannot fail to arouse a new interest in an already familiar scene.

In this book (the second of a series) Mr. Wymer bids you follow him into Essex, which he describes as so near London and yet, spiritually, "so remote from all that is going on in the outside world," and this remark is, I think, a clue to the theme of the book. Break from the roar of the traffic and read of strange country cures; of its farming and old harvest ceremonies; Morris dancing and the Dunmow Flitch. Into Suffolk and hear of its past woollen fame; the survival of its rural crafts; of its shepherds and wildfowlers. North into Norfolk, rich in her architecture, and read of her long battle against floods; of the ghosts of her noble houses; of Coke and Townshend and other famous names that spelt progress to the countryside. Through Cambridge and the open-dyked country of the Fens, you will read of the past history of Ely and the charm of Cambridge and its colleges.

You will be taken on through Huntingdon, Northampton, Rutland, Bedford, Hertford and Lincoln and follow the scenes through the hunting shires, and be reminded of the counties' associations with Cromwell, of Robert Bakewell, of Izaac Walton, of kings and noble lords.

Wheatsheaf and Willow will help you when you hear of the martyrdom of St. Edmund or see dancing around a maypole, to understand that this is history and the survival of tradition and custom so dear to the English. *Wheatsheaf and Willow* should not fail to interest a wide public.

P.J.O.T.

Keeping Chickens for Profit. ALAN THOMPSON. Nicholson and Watson. 6s.

Amateur poultry-keepers will welcome this addition to the series of *Country Books* edited by Brian Vesey-Fitzgerald. It is both practical and helpful and well worth the price charged for it.

The author has covered a fairly wide field relating to ordinary poultry-keeping, and the title might perhaps more appropriately have been " Keeping Poultry for Profit".

The book contains some excellent photographs and a large number of drawings by that eminent poultry artist, Bruff Jackson. These are particularly helpful and likely to be studied by readers with interest.

H.H.

A Horticultural Who Was Who. A. SIMMONDS. The Royal Horticultural Society. 3s

Who *was* Mr. Cox, whose "orange pippin" constitutes such a delightful legacy to all who appreciate a good apple; who *was* Mr. Bramley whose "seedling" has attained such lasting fame in the kitchen; and, more intriguing still, who was Annie Elizabeth? Was she wife or daughter of yet another of that engaging band of men in response to whose magic touch, seemingly, nature produces her choicest fruits?

Now, at last, thanks to Mr. Simmonds, we know all that is available about such worthies as Mr. Cox and Mr. Bramley, and others of pomological fame—Charles Ross and James Grieve. Sadly we learn that a child who died after a bare thirteen months' life had from her father a living memorial for ever in the form of a graceful orchard tree. But if Annie Elizabeth's fame is attributive, Mr. Bramley's, we learn, is vicarious. The honour of bringing a famous apple into the world belongs, really to Mary Ann Brailsford, of the same village (Southwell) where Mr. Bramley lived; for clearly it was her hands that sowed the seed in a flower pot.

Mr. Simmond's account of his patient research and sifting of facts and rumours, the wheat from the chaff, in order to acquire the truth, is very readable. It is difficult to put down such a book, and reading on we find ourselves in the world of flowers, encountering such well-known names as Mrs. Sinkins, Dr. Jules, Dorothy Perkins, and William Allen Richardson. We make the acquaintance of the men and women who originally bore these names. "What's in a name? That which we call a rose, by any other name would smell as sweet". But that Kentucky gentleman, of whom his friends said "He runs to roses," deserved his commemoration through such shapely and fragrant flowers as William Allen Richardson can give us in June.

There are chapters devoted to amusing details of two great gardeners, Paxton and Forsyth; the latter is pictured quixotically busy with the creation and marketing of a composition (Forsyth's "plaister") for treating the wounds of fruit and other trees—evidently he ran as a sideline a kind of quack-doctoring of trees.

All too soon this little book of engaging interest comes to an end with a study of George Cruikshank's coloured etching, produced in 1826, depicting in caricature style a meeting of the Horticultural Society. Under Mr. Simmonds's scrutiny many contemporary "characters" emerge from this drawing for our entertainment.

There will be many readers who, like myself, will wish there were more of this book than its 80 pages. For whatever the subject, the author's ingenuous style of writing attracts and holds the reader. But the author seems happiest, and so are we, when on those little pilgrimages to the former abodes of Mr. Cox, Mr. Bramley, and Annie Elizabeth.

A.H.H.

Vegetable Growing. J. E. KNOTT. Henry Kimpton. 20s.

The fact that this is a book about vegetable growing in America does not detract from its merit as a useful work of reference for growers in this country. It endeavours to cater for the small producer as well as for those growing vegetables under field conditions. A wide range of vegetables is covered, and the classification by temperature requirements should make a particular appeal to growers in climatically favoured areas, or to those with "forwarding" structures;

Specialist information is given in such sections as those on Sweet Corn, Cucurbits, and Beans, and the advice on the principles of production is equally applicable to this country. This is supported by useful data, in tabular form, on such matters as the quantities of seeds and plants required, with details of crop yields.

One Table shows the relative values of green manures, and it is interesting to note that in America much greater use seems to be made of nutrient solutions on seedlings. Useful information is given on this technique as well as on the general use of fertilizers.

Comprehensive cultural details are given under the various vegetable groups, and the suitability of varieties on the long and short-day principle are discussed. Various labour-saving methods are also a feature of these detailed cultures. The cultural advice embodies most of the recent findings on pest and disease control and on weed suppression by cultural and other means, including growth-regulating substances and the use of flame guns.

Great emphasis is laid on good seed stocks and the right selection of seed parents. Seed incubation and testing, including the "rag doll" method, are described. Tables show plant expectations from given numbers of seeds. Some of the figures are surprisingly low.

Seed pelleting for easy drilling is discussed, and bulk increases up to thirty times the weight of the seed are mentioned. Uniformity of spacing is said to be outweighted by the disadvantage of increased bulk.

In view of the book's attractive cover, it was disappointing not to find more information on the mechanization of vegetable growing. The home producer imagines that he has much to learn from the Americans about labour saving and the advantages of large-scale production, and greater detail of some of the operations illustrated would have added to the the value of the publication.

Marketing, mainly as it affects the small producer, is only briefly covered, but the section dealing with waxing, cold storage, etc., of produce should be of great interest to growers in this country who wish to extend their marketing season or to minimize their losses during glut periods.

A particularly valuable Table gives the optimum storage temperatures and maximum periods for which various vegetables can be held. This, alone, makes the book worth while.

H.W.A.

Insect Pests of Glasshouse Crops, HERBERT W. MILES AND MARY MILES. Crosby Lockwood. 15s.

There has been a long felt need for a revised edition of this well-known book on insect pests of glasshouse crops. As Professor of Horticulture at Wye College, Dr. Miles has continued to keep in touch with economic entomology and ever since the first edition has been out of print, advisory entomologists as well as teachers and growers have looked forward to the appearance of a second edition of this work.

There will undoubtedly be general approval of the modified presentation, the alphabetical list of crops, now coming as it does at the end of the first chapter, will make for ease of reference and the general chapter on methods of pest control is better situated near the beginning of the book.

Most of the advances recently made in glasshouse pest control are briefly discussed, but the authors warn growers not to be too hasty to be 'off with the old and on with the new'. Many readers, however, will be disappointed to find only brief references to the newer insecticides and new methods which have now had many trials and which already may be said to have become established. Only very brief mention is made of the use of smokes and aerosols and the control of the greenhouse red spider mite with azobenzene is dismissed in two lines.

Outstanding features of the first edition of this work were the quality and number of illustrations and the authors and publishers are to be congratulated on maintaining the high standard originally set; there are twenty-four plates comprising ninety-two excellent illustrations of glasshouse pests and the damage they do.

I.T.

BOOK REVIEWS

John Innes Horticultural Institution Annual Report 1948.

During the year 1948 the removal of the John Innes Horticultural Institution from Merton to a larger site at Bayfordbury, Hertfordshire, began in earnest. The task of moving a research centre is no small undertaking, and much care and forethought are required in order not to break unduly the continuity of investigations in hand. Work at the John Innes Institution has always been of a twofold nature. First, there are the investigations into matters of immediate practical importance to the grower of fruit, vegetables and flowers, notably fertility and pollination in fruit plants, the growing of sweet corn and tomatoes, and the development of special seed-raising and potting composts. Second, there is the valuable scientific work concerned with the genetical constitution of a wide range of cultivated plants—work that has not only provided new knowledge but has led to a clearer understanding of the science of plant breeding, so long a tangled path with many blind alleys for the unwary. The Director and his staff are deserving of congratulations in that there has been no appreciable break, no hiatus as it were, in the many valuable investigations.

The report states that about 65 acres at Bayfordbury have been taken over for use since the property was acquired in 1945-46. The planning of this area includes the allocation of about 5 acres to the establishment of a National Rose Collection in co-operation with the Royal Botanic Gardens, Kew, and the Royal Horticultural Society's Gardens, Wisley.

In the Pomological Department, Mr. M. B. Crane has continued his genetical and breeding studies of fruit plants, notably pears, raspberries and tomatoes.

In the Genetics Department, work under Dr. K. Mather has been concerned in recent years mainly with the organization, properties and analysis of the polygenic systems which control quantitative or continuous variation. As was to be expected, a number of diverse lines of experiment have developed from this work. In October of the year under review Dr. Mather left the Institution to take up the newly-created chair of genetics at Birmingham University.

An interesting feature of the Cytology Department's work is the inquiry undertaken into the origin of garden daffodils—work that involved a painstaking survey of representative forms of the enormous number of cultivated clones whose ancestors are two highly polymorphic species of *Narcissus*.

Reporting generally on the work of the Institution, the Director concludes with some interesting observations on the Lysenko-Michurin claims, which deserve close attention. As is now well known, Lysenko claims to have achieved what may be termed "vegetative hybrids" by grafting together different species of plants and raising seed from them. The workers at the John Innes Institution have had very considerable experience of cross-grafting, and have closely studied the subject of cytoplasmic inheritance. So far they have encountered no evidence to support the claim by the Michurin-Lysenko school that cross-grafting can be a means of producing new and improved plants of a true hybrid nature.

This report of the John Innes Institution for 1948 is worth close study by all who take an intelligent interest in scientific horticulture.

A.H.H.

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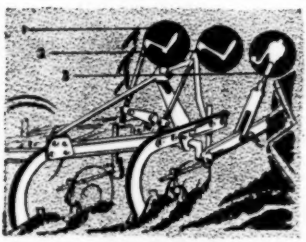

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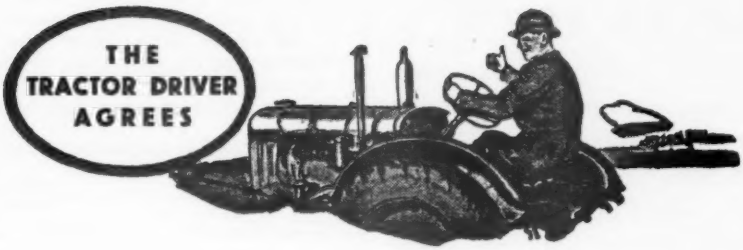

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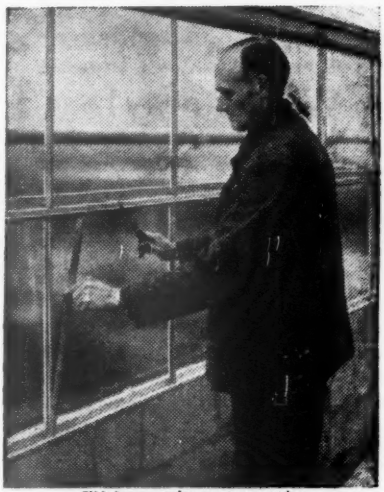

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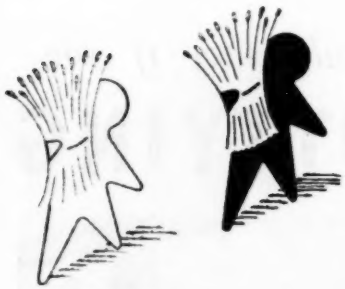

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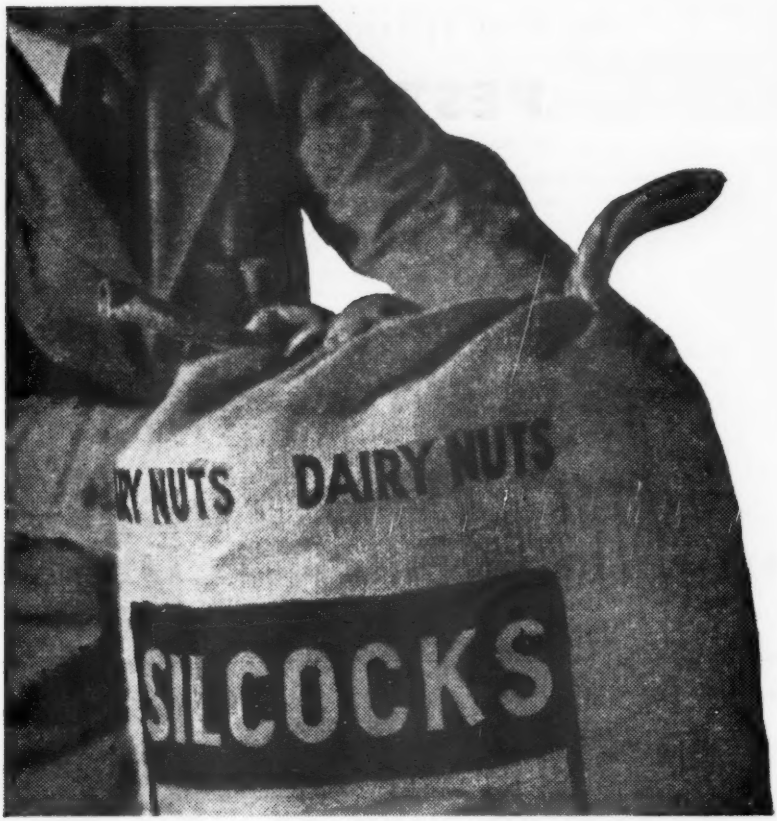

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Peanut aphis	*Aphis laburni*
Hop red spider	*Tetranychus telarius*

Pestox 3 is the outcome of intensive work by a large research team of entomologists, chemists and doctors working on systemic insecticides at the Pest Control Research Station, Bourn, Cambridge, and the research laboratories of the Pest Control overseas companies.

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* *A systemic insecticide is absorbed into the sap-stream of the plant.*

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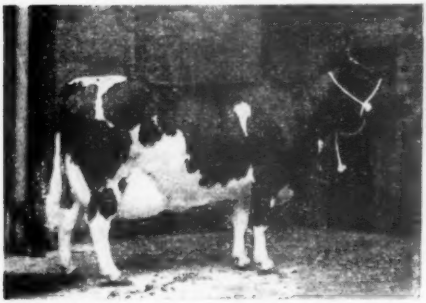

Photo : Sport and General

DAIRY SHOW Winners

Supreme Champion

OVERTOUN CHERRY FINE owned by W. H. Slater, Esq., Eyton Farm, Wellington, Salop. Won the Supreme Individual Championship Challenge Trophy ; Barham Challenge Cup ; Spencer-Stapleton Perpetual Challenge Cup ; National Milk Challenge Cup ; Rowallan Cup ; Eyton Perpetual Challenge Trophy and together with her daughter "Sheriffhales Fine Cherry" won the Thornton Challenge Cup.

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Photo : Sport and General

Highest Milk Yield

SOMERS KIT owned by G. C. Goodchild, Esq., Flampsteds Farm, Ashley Green, Chesham, Bucks. She gave the highest milk yield of the show—102.1 lbs., the second highest ever at the London Dairy Show. (Record 102.65 lbs. in 1929).

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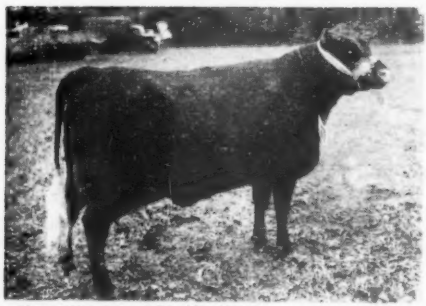

Photo : Farmer and Stockbreeder

Milking Trials Success

PAKENHAM POSY 2nd owned by Messrs. S. W. Cross & Sons Ltd., Ixworth, Bury St. Edmunds, Suffolk. She was first in Milking Trials, Red Poll Heifer Class.

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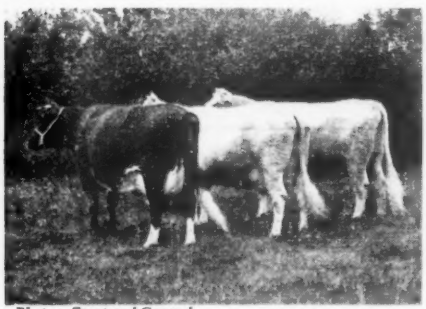

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Thornton Cup

CHURCHILL PRIMROSE 35th, 47th and 52nd owned by T. A. Rose, Esq., Churchill Heath, Kingham, Oxon. These three cows won the Thornton Cup for the best three in Dairy Shorthorn Class.

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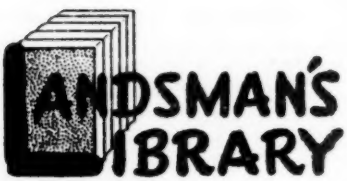

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